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Master Thesis

Organisational Adaption in the German Automotive Industry after the Emission Scandal

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Marius Peters

Declaration of Confidentiality

The thesis by *Marius Peters* with the title "Organisational Adaption in the German Automotive Industry after the Emission Scandal" was supervised by the following university faculty members:

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Abstract

In September of 2015 it was uncovered that the Volkswagen Group (VW) has been manipulating emission tests and statistics on a wide range of its diesel vehicles. This thesis explores organisational adaption of manufacturers from the German automotive industry after the emission scandal with a single case study approach. The results give four main insights. First, German manufacturers did not show a significant operational reaction to the scandal, as neither consumer preferences, nor environmental regulation changed immediately. Second, the emission scandal seems to have reduced uncertainty about future environmental regulations among manufacturers, which led firms to adjust their strategic behaviour. Third, firms re-evaluated and adapted ambidexterity in their organisation. Whereas electric mobility focusses on more exploitative search processes to achieve economies of scale and scope for industrialisation, internal combustion engine (ICE) technology needs more explorative search processes to simultaneously remain compliant with worldwide regulation and maintain a competitive cost position. Fourth, managers showed mixed results regarding the framing of change as either opportunity or threat.

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Abbreviations

ACEA	European Automobile Manufacturers Association
BAFA	Bundesamt für Wirtschaft und Ausfuhrkontrolle
BEV	Battery electric vehicle
BMVI	Bundesministerium für Verkehr und digitale Infrastruktur
CAFE	Corporate Average Fuel Economy
CO	Carbon monoxide
CO_2	Carbon dioxide
EBIT	Earnings before interest and tax
EFTA	European Free Trade Association
EPA	Environmental Protection Agency
GmbH	Gesellschaft mit beschränkter Haftung (limited liability company)
NHTSA	National Highway Traffic Safety Administration
HI	Herfindahl Index
ICCT	International Council on Clean Transportation
ICE	Internal combustion engine
KBA	Kraftfahrt-Bundesamt
LEV	Low emission vehicle
MSRP	Manufacturer's suggested retail price
NO_x	Nitrogen oxide
NEDC	New European driving cycle
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid vehicle
RDE	Real driving emission
SCR	Selective catalytic reduction
WLTP	Worldwide Harmonised Light Vehicle Test Procedure
YoY	Year-over-year

1. Introduction

In September of 2015, it was uncovered that the Volkswagen Group (VW) has been manipulating emission tests on a wide range of its diesel vehicles. A defeat device detected, when the car was undergoing a testing situation and changed engine settings accordingly to reduce air pollutants. Consequently, the scandal currently questions the future of diesel vehicles as category and several manufacturers introduced new strategies to accelerate roadmaps for a transition to low emission vehicles (LEV). The event has the potential to change the dynamics of the industry in the long run, however it is currently unknown if and how the emission scandal affected incumbent firms that were not engaging in the manipulations. In this context, the thesis explores the organisational adaption of manufacturers in the German automotive industry to changes in exogenous factors (environmental regulation and consumer preferences) after the emission scandal. The following research question will guide the thesis:

If and how did car manufacturers in the German automotive industry adapt to perceived changes in consumer preferences and environmental regulation after the emission scandal?

To answer this question, a case study on firm behaviour in the industry is conducted with a German manufacturer from the premium segment. Nine in-depth interviews with high-level employees from different departments and sales subsidiaries in Germany, the United States and the United Kingdom were conducted and analysed in a coding and pattern matching process.

The results give four main insights: First, German manufacturers did not show a significant operational reaction to the scandal, as neither consumer preferences nor environmental regulation changed immediately. Second, the emission scandal seems to have reduced uncertainty about future environmental regulations among manufacturers, which led firms to adjust their strategic behaviour. Third, firms re-evaluated and adapted ambidexterity in their organisation.

Whereas the trajectory of electric mobility focusses on more exploitative search processes to achieve economies of scale and scope for industrialisation, internal combustion engine (ICE) technology needs more explorative search processes to simultaneously remain compliant with worldwide regulation and maintain a competitive cost position. Fourth, managers showed mixed results regarding the framing of change as either opportunity or threat, suggesting that the changes introduced by the emission scandal still face internal barriers.

The remainder of the thesis will be structured as follows: The first chapter provides an overview of the automotive industry, its regulation and relevant background information on the emission scandal. In the second chapter, a literature review on organisational adaption theory is conducted and complemented by empirical evidence for the influence of consumer preferences and environmental regulation on firm behaviour in the automotive industry. With this information, the research question and three investigative question are derived (chapter five). Subsequently, the case study approach and interview setup is explained in detail (chapter six). Chapter seven provides the results of the coding process as the analysis and structuration of the interview data. Firm-perceived changes in demand and exogenous factors, as well as changes in operational and strategic firm behaviour are described. Building on these results, chapter eight uses theoretical concepts to establish connections between changes in the perception of exogenous factors and organizational adaption. Finally, chapter nine discusses managerial implications and academic contributions of these results and gives directions for future research.

2. The Emission Scandal in the Automotive Industry

2.1. The German Automotive Industry

There are four major original equipment manufacturers (OEMs) in the automotive industry, which were founded and are still headquartered in Germany: Volkswagen Group, Daimler AG, BMW Group and Adam Opel AG[1]. *Table 1* provides an overview of key metrics of these companies (based on Volkswagen Group, 2015c; Daimler AG, 2015; BMW Group; 2015; General Motors Company, 2015). Together these manufacturers sold 12.7 million passenger car units in 2015, which represents approximately 17.5% of worldwide new vehicle sales (Statista, 2016a). The result is almost €400 billion in revenue and €28 billion in earnings before interest and tax (EBIT).

Table 1: *German OEMs & 2015 Key Figures*

OEM	Passenger Car Units [Million]	Passenger Car Revenue [Billion €]	Passenger Car EBIT [Billion €]	Passenger Car EBIT Margin [%]	Passenger Car Brands
Volkswagen Group	7.4	209.2	11.6	5.5	VW, Audi, Porsche, Seat, Skoda, Bentley, Lamborghini, Bugatti
Daimler AG	2	83.8	7.9	9.4	Mercedes Benz, Mercedes-Maybach, Smart
BMW Group	2.2	85.5	9.2	10.8	BMW, MINI, Rolls-Royce
Adam Opel AG (GME)	1.1	16.9[2]	- 0.7[2]	- 4.1	Opel, Vauxhall
Sum	**12.7**	**395.4[2]**	**28**		

German OEMs target market segments with different generic strategies and brands in their portfolio. This is reflected in their EBIT-margins (Statista, 2015a). Brands from the medium segments, such as Volkswagen, are only able to achieve approximately 5% and are dependent on high sales volumes. The premium brands Mercedes, Audi and BMW are continuously able to

[1] Adam Opel AG is a subsidiary of General Motors, but was included here, as it is headquartered in Germany.
[2] Monetary values reported in US Dollar were converted to Euro with the 2015 reference price (Deutsche Bundesbank, 2015)

achieve approximately 10%, whereas the luxury segments (e.g. Rolls Royce, Bentley, Lamborghini) can achieve more than 15%. These two segments pursue differentiation or focus strategies to achieve profitability.

2.2. Market Structure

The total market size for new passenger vehicles worldwide was 72.37 million units in 2015 (Statista, 2016a). The most important geographic markets for car manufacturers are Western Europe (13.1 million units; ACEA 2016a), the United States (7.7 million units; Statista; 2016b) and Asia, including China (21.7 million units; Statista, 2016c) and Japan (4.2 million Units; Statista, 2016d). These regions collectively make up two thirds of new car sales worldwide.

The focus of this thesis will be on western Europe (EU15+EFTA). To gain deeper insights into its structure, new car registration data was received from the *European Automobile Manufacturers Association* (ACEA, 2016a) and *Eurostat* (2016).[3] A more detailed overview of the data is provided in *Appendix 1*. The market shows mixed growth rates over the past five years ranging from -8.1% to +8.3%. Concentration ratios are stable over the last five years (C_4≈52%, C_6≈66%), as is the Herfindahl Index (HI) at 0.11. However, the market is less competitive than the index suggests. Consumers do not perceive all products as perfect substitutes and manufacturers target market segments with differentiated brands. From that perspective, the overall market shows evidence for monopolistic competition. Firms are not so much reacting to firm behaviour across the industry, but to brands within their segment. Whereas the low-cost segment is very competitive (HI=0.12), the medium (HI=0.18), premium (HI=0.20) and luxury segments (HI=0.68) are less competitive (see *Appendix 1*). The higher the average selling price,

[3] All numbers in this section are results of my own calculations based on ACEA, Eurostat and KBA new car registration data. New car registrations do not exactly match new car sales, but are the best approximation for the purpose of this thesis.

the less competitive are the segments. Within the medium and premium segment, in which German manufacturers sell their highest volumes, the market is assumed to be oligopolistic.
The data also provides insights on the respective market shares of drivetrain technologies. Diesel market shares grew rapidly over the last decades, as diesel vehicles are subsidised by the European Union through lower fuel taxes (approximately €2.600 per vehicle; T&E, 2015). The segment now makes up 51.6% of new car registrations (ACEA, 2016). Low emission vehicles (LEVs), running with alternative fuels, such as battery electric and hybrid vehicles, are growing as a category, but their overall share remains low at 4.4% in 2015.

Within western Europe, market structures can vary significantly across countries. For example, the German *Kraftfahrt-Bundesamt* publishes detailed monthly data on new car registrations (KBA, 2016a), which reveal that the German market is more concentrated (Herfindahl Index: 0.19).[3] Consumers appear to favour German OEMs, which make up 67.4% of sales. New car sales were driven by business purchases, as private purchases only account for a third of new registrations. Furthermore, low emission vehicles gained less traction in this market than on a European level (1.8% market share).

2.3. Market Regulation

Internal combustion engine (ICE) vehicles produce global air pollution through carbon dioxide (CO_2), which is a driver of climate change, and local air pollutants, such as nitrogen oxides (NO_x) and carbon monoxide (CO). Both are subject to regulations, which are established at the European level by the European Parliament.

First, the European Parliament sets maximum emission standards for local air pollutants in passenger vehicles (European Parliament, 2007). The current standard in place is *Euro 6b*, which became mandatory for new vehicle admissions in 2014 and limits local air pollutants to 8% of the initial *Euro 1* -level from 1990 (ICCT, 2016a). Furthermore, each car has a badge displaying

its emission class in the front window, limiting its usage in certain urban areas. Second, car manufacturers must meet an average fleet CO_2 emission standard for their new vehicle sales. In 2015, the target was set at an average of 120g CO_2/km, however deviations are possible, depending on the specifics of the manufacturer's product portfolio (European Parliament, 2009). In 2014, the target was renewed for the year 2021 at an average of 95g CO_2/km (European Parliament, 2014). To give companies some flexibility, as well as an incentive to be first mover, super credits are granted for the introduction of low-emission vehicles or other environmental innovations, which are not measurable in standardised testing (BMVI, 2016a). Non-compliance with these standards is penalised by a fee.

The challenge for manufacturers is to ensure worldwide compliance with emission regulation, while minimising engine development costs. In general, means of emission regulation are quite similar in other markets (ICCT, 2015). For example, the United States have corporate average fuel economy standards (CAFE) set by the National Highway Traffic Safety Administration, which work quite like European fleet targets (NHTSA, 2016). Nevertheless, the exact amount of emission reduction to be achieved varies from market to market. For example, a new European standard beyond the given timeline is to be decided in 2018 and still depends on the rate of acceptance of low-emission vehicles by the market (BMVI, 2016a; VDA, 2016a). The US Environmental Protection Agency (EPA) on the other hand is aiming for a linear reduction of emissions by 4-5% each year (Triplett, 2016).

Another challenge for manufacturers is that each market uses different test cycles to measure emission levels. The most relevant ones are the New European Driving Cycle (NEDC), the EPA Federal Test Procedure (USA) and the Worldwide Harmonised Light Vehicle Test Procedure, which will replace NEDC in the future (ICCT, 2015; EPA, 2016a). These tests vary in regards to starting temperature, gear shifts, car-preconditioning, additional weight and other factors (ICCT, 2014). To minimise development costs, manufacturers started optimising their vehicles

towards the specific testing procedures. Furthermore, the European Parliament announced the introduction of real driving emissions test (RDE) to accompany laboratory tests, as the lack of airstream in laboratory tests leads to significantly lower results than consumers experienced on the road (ICCT, 2016b). The ICCT (2016b) found that the gap between official and real-driving values increased from 9% in 2001 to 42% in 2015.

2.4. Chronology of Events

In September 2015, it was uncovered that Volkswagen has been manipulating emission tests of their diesel vehicles with a defeat device to obtain admission of their cars in Europe, the United States and other markets (EPA, 2016b). Software, which recognised whether the car was undergoing a test situation, changed engine settings to reduce emissions. Some models were found to produce up to forty times the amount of nitrogen oxides compared to real-world driving situations (EPA, 2016b). The scandal was first uncovered by the International Council on Clean Transportation in the United States (ICCT, 2016a). The agency had been investigating the manufacturer since 2014, when Volkswagen blamed increased emissions on a non-intended software bug and recalled half a million vehicles. In 2015, the California Air Resources Board, retested affected vehicles in several non-standardised driving situations and was still able to replicate previous results (Zeit, 2016). Under the threat of withdrawing vehicle admission licenses, Volkswagen admitted to having engaged in manipulations on 11 million vehicles worldwide, including approximately 600.000 vehicles in the United States and 8.5 million vehicles in Europe, 2.5 million of which in Germany (Volkswagen Group, 2015a; EPA, 2015; BMVI, 2016b). Consequently, Volkswagen had to make provisions of more than €16 billion for expected upcoming lawsuits and repairs, reported its first quarterly loss in twenty years and replaced several board members, including CEO Martin Winterkorn (Volkswagen Group, 2015b). Volkswagen's shares declined by 40% within hours after the scandal broke. Moreover, the rest of the car industry was affected as well. Shares of other automotive companies dropped by two to four percent (Gallant, 2016).

Two months later, Volkswagen's subsidiaries (Audi, Porsche, Skoda, Seat) were also charged for manipulations in diesel vehicles, as they were using the same parts (EPA, 2015). In January of 2016, the US department of justice filed a lawsuit against Volkswagen for violating air purity laws. The lawsuit was settled in March, as Volkswagen agreed to extensive buybacks of affected vehicles. A similar settlement did not take place in Germany, as it was denied by VW. Instead, all affected vehicles were recalled in tranches for maintenance (BMVI, 2016b). New class action lawsuits, for example by car dealerships and numerous pension and investment funds followed throughout 2016 (Balser, Fromm & Ott, 2016).

2.5. Motivation for Non-Compliance

In engine development, the reduction of local and global air pollutants requires conflicting measures, which leads manufacturers into a trade-off. For example, engines running at a higher temperature emit less CO_2, but more NO_x and vice versa (ACEA, 2016b). Whereas CO_2 emissions are directly related to fuel consumption, the amount of local air pollutants emitted is unrelated (Parry, Walls & Harrington, 2007). For these reasons, diesel vehicles produce less CO_2, but more NO_x. To solve the trade-off, manufacturers equip their cars with exhaust after-treatment systems and selective catalytic reduction (SCR), which use chemicals to further reduce local air pollutants. Manufacturers face disproportionate development costs for each additional decrease in emissions (Umweltbundesamt, 2008). Thus, emission regulations impose significant restrictions to car manufacturers in their new car development processes. From a technical perspective, the 2015 target can barely be achieved by a portfolio of internal combustion engines, while maintaining a competitive cost position (VDA, 2016b). Instead of implementing further emission reduction technology, Volkswagen used the engine's software as an illegal defeat device (EPA, 2016b). The software then optimises engine settings to reduce both local and global air pollutants at the sacrifice of vehicle performance. After-treatment systems and SCR was found to only operate at full capacity, when a testing cycle is recognised.

3. Problem Statement

So far, it is still unclear how the emission scandal has impacted the German automotive industry, especially firms other the Volkswagen Group, which were not engaged in the manipulations. The Volkswagen Group's brands compete in the same segments as other manufacturers from Germany. Therefore, it is assumed that these companies will show a reaction to the events of the emission scandal. Furthermore, the event has the potential to affect the long-term dynamics of the industry by changing exogenous factors in the market. At this point, it is unknown yet, whether market conditions and firm behaviour have been impacted significantly. Therefore, the following problem statement will guide further development of a more concrete theoretical framework for the analysis:

How did the emission scandal affect German manufacturers in the automotive industry?

4. Theoretical Framework

4.1. Organisational Adaption Theory

4.1.1. Definition and Characteristics of Exploration & Exploitation

This thesis will use organisational adaption theory as a framework to assess firm behaviour. The theory places the individual firm at the centre of analysis. In the simplest model firms make sequential decisions under uncertainty, whether they should keep exploiting their current business model, or explore alternatives to maximise future cash flows (Posen & Levinthal, 2012). Thus, strategic firm behaviour is analysed in the two dimensions exploration and exploitation.

The literature offers several definitions for these constructs. According to March (1991, p. 85), exploitation is defined as "(…) the refinement and extension of existing competencies, technologies, and paradigms". This includes local search processes, experimental refinements and the optimisation of existing routines. The firm makes "ongoing use" of its existing knowledge base (Vermeulen & Barkema, 2001, p. 459) Thus, exploitation is most likely to yield incremental innovation and short-term results (Atuahene-Gima, 2005; Wang & Rafiq, 2014). In contrast, exploration is defined as "(…) the pursuit and acquisition of new knowledge" (Gupta, Smith & Shalley, 2006, p. 693). Exploration has a higher potential to yield radical innovation by trying to break path-dependent behaviour, however its benefits are more uncertain and most likely only occur in the long run (Atuahene-Gima, 2005; He & Wong, 2004; Wang & Rafiq, 2014). The given definitions clearly do not distinguish the constructs by representing the presence or absence of learning processes in the organisation. Both concepts are learning processes, which differ in the amount and type of learning (Gupta et al., 2006). Katila and Ahuja (2002) describe the concepts as search efforts across two different dimensions: Whereas the amount of exploration determines the scope of search efforts, exploitation determines the depth of search within each trajectory.

The two concepts are self-reinforcing. Focusing the organisation on exploration can lead to a "failure trap" (Gupta et al., 2006, p. 695), where the continuous lack of successful explorative activities leads the company to engage even more in explorative activities. On the other hand, a high degree of exploitative activities can lead the firm into a "success trap" (Gupta et al., 2006, p. 695). Exploitation aims to achieve short-term profits through optimisation, therefore it tends to give managers an incentive to keep engaging in these activities. Firms face the need to balance exploration and exploitation in their organisation, as a focus on either one is not sustainable (Gupta et al., 2006; He & Wong, 2004; Wang & Rafiq, 2014).

Simultaneously engaging in exploration and exploitation imposes managers with a paradox. The two concepts need fundamentally different resources and processes, as well as management approaches (Gupta et al., 2006; Tushman & O'Reilly, 1996; Wang & Rafiq, 2014). Firms must distribute limited financial resources across either relatively certain short-term benefits and more uncertain long-term opportunities (March, 1991). The performance of both activities will be suboptimal, if they are pursued simultaneously. An investment in explorative activities might decrease the expected payback of a firm's current business model, because companies de facto make investments, that could render their current core competencies useless in the future (Atuahene-Gima, 2005). For example, the German automotive industry currently faces this trade-off. Their core competency is the development and industrialisation of vehicles with internal combustion engines (ICEs). This competence provides them with a sustainable competitive advantage, as it yields a superior driving experience for its customers. Battery electric vehicles on the other hand cannot be differentiated through engine technology, as engines are replaced with solenoid coils, running off electricity. Thereby, manufacturers are inhibited to invest into advancements of electric mobility in their product portfolios.

The literature predominantly offers two concepts to solve the trade-off, namely ambidexterity and punctuated equilibrium. Tushman and O'Reilly (1996) first described the need for ambidex-

trous organisations. Ambidexterity is defined as "(…) the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits" (Gupta et al., 2006, p. 693). Exploration and exploitation are treated as mutually exclusive in regards to their resource demands. Therefore, they should be separated within the organisation. An interface should foster an exchange between the two subunits to coordinate and co-specialise their resource requirements (Atuahene-Gima, 2005; Gupta et al., 2006). The interaction between the two concepts was found to have a positive effect on new product development (Katila & Ahuja, 2002). Firms clearly benefit, if the two units yield complementary knowledge, because they can use current competencies to leverage new ones and moderate the trade-off (Atuahene-Gima, 2005; Posen & Levinthal, 2012). Long-term developments on the other hand can be explained by the punctuated equilibrium model, stating that long phases of exploitation are followed by short phases of intense exploration. Consequently, either exploration or exploitation should be at the strategic focus of each individual subunit at any given point in time (Kim, Song & Nerkar, 2012). As exploitation is dependent on a stable environment, the organisation will adapt to changes in the environment by switching its focus to previously explorative activities, until learning processes allow it to compete in a new environment (Gupta et al., 2006).

Ambidexterity and punctuated equilibrium are not contradictory in their setup (Gupta et al., 2006). If resource limitations do not restrict the firm to either explorative or exploitative activities, it can pursue both in individual subunits. Long run adoption across the subunits will then occur via ambidexterity, but each subunit will then experience punctuated equilibria, as its focus shifts from exploration to exploitation and vice versa.

4.1.2. Influence of Changes in Exogenous Factors

Rapidly changing market situations can render a shift from simultaneous development towards short phases of intense exploration necessary, as a radical innovation replaces a current product

(Gupta et al., 2006). Thus, balancing ambidexterity is a more demanding task in highly dynamic environments.

Changes in exogenous factors can render existing knowledge within the organisation useless (Posen & Levinthal, 2012). For this reason, the general expectation in strategy literature is that companies should change their focus to explorative activities when the rate of change in the environment increases (punctuated equilibrium). Uncertainty and complexity in the environment make it necessary to re-evaluate, whether the current knowledge can lead to a sustainable competitive advantage (Kim et al., 2012). Nevertheless, it cannot be assumed that a switch to exploration is always the better strategy, as a highly dynamic environment also makes the rewards of exploratory activities even more uncertain (Posen & Levinthal, 2012). As soon as radical innovations could be introduced to the market, the environment might have already changed because of longer development lead times. Posen and Levinthal (2012) propose an inverted u-shape relationship between the rate of change and the rewards of explorative activities. A shift to exploration is most promising, when the external environment is neither stable, nor very volatile, and when change devalues existing knowledge. Hence, the challenge for firms is to correctly evaluate changes in exogenous factors (Atuahene-Gima, 2005).

4.2. Empirical Evidence from the Automotive Industry

The thesis will focus on two relevant factors of exogenous change: Environmental regulation and consumer preferences. The following subsections will provide empirical evidence on their relevance for the automotive industry prior to the emission scandal.

4.2.1. Environmental Regulation and Firm Behaviour

The automotive sector is a source of several externalities in the economy, such as global and local air pollutants. Parry, Walls and Harrington (2007) provide an overview of their effects. Global air pollutants are greenhouse gasses, such as CO_2, which are driving climate change. On

the other hand, local air pollutants, such as NO_x, do not cause externalities on a global level, but lead to negative health (e.g. cardiovascular effects) and economic effects (e.g. agriculture). Both externalities are exacerbated by traffic congestion in urban areas, as there is a u-shaped relationship between average vehicle speed and emission levels (Parry et al., 2007).

Regulation plays a key role in the reduction of these externalities by inducing the development, as well as the adoption, of green technologies (Bergek & Berggren, 2014; Blind, 2012; Lee, Veloso & Hounshell, 2011). The industry is regulated by technological standards, emission standards (maximum emission level) and performance standards (emissions per output), but firm behaviour is also influenced indirectly through vehicle taxes, fuel taxes and subsidies for customers (Barbieri, 2015). Each instrument has different effects on firm behaviour.

Regulatory instruments, such as emission standards, have a significant impact on innovation activities. With consumers showing little additional willingness to pay for emission reduction technologies, these standards tie a significant percentage of R&D budgets to their development and hence force their implementation in production vehicles (Parry et al., 2007). The government gives little concrete technological direction, but provides firms with R&D incentives through subsidies for the development of certain technologies, such as electric mobility (Blind, 2012). This leads to more radical modular innovation compared to an increase in fuel taxes (Bergek & Berggren, 2014). If a specific technological development is incentivised, this can accelerate the introduction of the technology to the market, but no further effect on their continuous development can be guaranteed (Bergek & Berggren, 2014).

The stimulation of emission reduction within ICE technology does not always lead to lower emissions throughout the vehicle lifecycle, as the new technology often reduces consumers' post-purchase costs. Thus, all gains in emission reduction are partially offset by consumers increasing their mileage (Parry et al., 2007). Fuel taxes can counteract this effect by providing

consumers with incentives for avoiding pollution. Indirectly, fuel prices then influence innovation activities at manufacturers through customer preferences (Aghion, Dechezlepretre, Hemous & van Reenen, 2016). However, this effect was found to only yield incremental technological advancements as well (Bergek & Berggren, 2014).

Stimulating radical innovation, as well as consumer adoption, appears to be a big challenge for regulators. Instead, it is assumed that many gradual small changes in subsystems can in the end lead to more radical changes, as manufacturers slowly reach a tipping point, at which ICEs are no longer feasible (Hillmann & Sandén, 2008). Environmental regulation does not simply have to be a cost restriction for incumbent firms. The Porter Hypothesis (Porter, 1990) suggests that environmental regulation has to be strict, but flexible at the same time. Policies need to take the dynamics of the industry into account to balance different technological trajectories with market forces (Hillmann & Sandén, 2008). If correctly formulated, a win-win situation will be created, in which firms can offset the cost of compliance and even increase business performance and firm competitiveness (Ambec, Cohen, Elgie & Lanoie, 2013). However, there is criticism towards this hypothesis. Environmental regulation might induce the development of environmental technologies, but the theory denies their social desirability (Kneller & Manderson, 2011). Furthermore, companies were found to not increase their R&D budgets, but simply shift financial means away from other departments. The result is a suboptimal expenditure on non-environmental innovation, which is desired by the customer. Firm margins decrease and a win-win situation becomes less likely (Kneller & Manderson, 2011).

4.2.2. Consumer Preferences and Firm Behaviour

Consumer preferences might be a stronger driver of explorative firm behaviour, as market selection processes can be more radical than regulation-induced incremental innovation (Unruh, 2002). Currently, low-emission vehicles are still niche products. Dijk and Yarime (2010) found, that consumers can be divided in three clusters of engine choices: 35% choose cheapest engine

(which is usually quite fuel efficient), 60% choose sporty driving over fuel economy and only 5% pay a premium for better fuel economy in LEVs. A low-emission model is therefore often unavailable in manufacturers' product portfolio, or does not provide a strong enough emission reduction to be economically attractive.

Low emissions are not among the primary purchase reasons for new car buyers. Car class is usually the first decision, which then largely determines CO_2 emissions due to weight (Nayum, Klöckner & Prugsamatz, 2013). This leaves car manufacturers with unattractive market conditions for sustainable technologies, such as electric mobility (Bohnsack, Pinkse & Kolk, 2014). Nonetheless, Dijk, Orsato & Kemp (2013) think that a significant shift in consumer preferences is a possible scenario, if the image of ICE vehicles decreases.

For now, the adoption of electric mobility is hindered by pricing, fuelling infrastructure and existing consumer usage patterns (Dijk et al., 2013). Car-sharing firms are already serving individual mobility needs in urban areas. Their business model solves problems with pricing and infrastructure, as well as purchase risk, by making the technology affordable for the mass market with a pay-per-use approach (Dijk et al., 2013). These firms are potentially only the beginning of greater changes in the industry. For example, McKinsey & Company (2016) predict that digitalisation and new business models will change individual mobility through four major trends until 2030: connectivity, autonomous driving, electrification, and diverse mobility.[4] As mobility patterns continue to shift, car manufacturers are increasingly challenged rethink their traditional business models (Dijk et al., 2013).

[4] Diverse mobility are new modes of transportation and the modular combination of public and private means of transportation, for example 'Park+Ride'.

5. Question Hierarchy

The events of the emission scandal have the potential to change exogenous factors in the automotive industry. This thesis will focus on the two factors consumer preferences and environmental regulation. If the emission scandal changed these factors in the market, incumbent manufacturers will have to adapt by re-evaluating ambidexterity in their organisation. Therefore, the initial problem statement can be narrowed down to the following research question:

If and how did car manufacturers in the German automotive industry adapt to perceived changes in consumer preferences and environmental regulation after the emission scandal?

The research question of this thesis can be further divided into three investigative questions. In a first step, changes in firm perception of consumer preferences, environmental regulation and firm behaviour need to be established:

(1) How did incumbent firms perceive changes of exogenous factors in the market after the emission scandal?
(2) How did incumbent firms adapt their strategic and operational behaviour?

In a second step, connections have to be drawn between these changes:

(3) *Which perceived changes in exogenous factors led to which changes in firm behaviour and why?*

Concrete measurement questions will be formulated with regards to the methodology in the following chapter.

6. Methodology

6.1. Case Study Approach

A single case study approach was selected to answer the given research question. Case studies are an appropriate methodology, when trying to answer an explanatory research question, when the behaviour of participants cannot be controlled for in a reference group and when the boundaries of the context and the phenomenon are not clearly defined (Yin, 2003, p. 13). All three aspects hold true for the given research question, which is of exploratory and explanatory nature. On the one hand, more concrete information on the firms' perception of changing exogenous factor, as well as their operational and strategic firm behaviour needs to be explored. On the other hand, the gathered information needs to be connected to explain concrete firm reactions.

The emission scandal is a very sensitive topic for the automotive industry. For VW, as well as the supplier Bosch, the scandal led to law suits, which are still under investigation (Balser, Fromm & Ott, 2016). Second, the thesis deals with firm behaviour, which imposes participating firms to the risk of information leakage. Access to up-to-date and high quality data was limited. Thus, this thesis focusses on a single case. Due to my previous work experience in the German automotive industry, I was able to set up a feasible approach together with a manufacturer from the premium segment. To ensure confidentiality, the name of the firm will be anonymised and hereafter be referred to as '*the company'*. *The company* was not involved in the manipulations of the emission scandal, however it announced a new corporate strategy after the scandal with an increased focus on electric mobility. As the research question aims at identifying implications that go beyond firms that engaged in manipulations, the selected company can provide a unique perspective on firm behaviour in the German automotive industry in the time after the emission scandal (September 2015 – November 2016). The case study was developed through a

series of qualitative in-depth interviews. Further details on the interview setup will be provided in the following sections.

6.2. Interview Sample

In a first step to setup the interviews, the sample size was determined. The number of interview participants had to be agreed upon with *the company* in advance. Thereby it was ensured, that the study fulfils academic standards, but at the same time mitigates the risk of information leakage for *the company*'s internal supporter of my thesis.

From an academic perspective, the sample size should be determined by the principle of saturation (Mason, 2010). Several scholars try to operationalise the concept to a specific number of interviews, but there is little consensus in their findings. The minimum required sample size ranges from four to fifteen participants (Romney, Batchfelder & Weller, 1986; Guest, Bunce & Johnson, 2006; Mason, 2010). Instead of agreeing on a specific number, Guest et al. (2006) summarise that if the sample is of high quality, very few participants can be sufficient. They propose three criteria to be met, which are evaluated in *Table 2*.

Table 2: *Sample Criteria*

Criteria	Evaluation
(1) Participants must have a certain expertise about the topic.	All participants are in a mid- to high-level management position and on average sixteen years of experience in the automotive industry in different positions, companies and/or markets.
(2) The group of participants is homogenous.	As all participants are employees at *the company*, they should have the same information sources, however might evaluate them differently based on their previous experience and current position.
(3) The number of themes the researcher is looking for is small.	The thesis is of exploratory nature and treats changes in exogenous factors (environmental regulation, consumer pressure) and firm behaviour (organisational adaption theory) on a very broad level.

As a result of balancing academic standards with *the company*'s requirements, the number of participants was set at a maximum of ten, before the start of the data collection process. However, *the company* did not specify, who these participants should be. Each person was identified,

because they were deemed to have unique insights towards the research question (theoretical sampling, non-probabilistic) and were available during the time of data collection. *Table 3* gives an overview of all interview participants. The sample contains mid- to high-level employees from both the corporate headquarter, as well as sales subsidiaries in Germany, the United Kingdom and the United States. On average, the participants have sixteen years of work experience in the industry. Eight participants have a university degree, two of which carry a Ph.D. title. Employees from the corporate headquarter consisted of product managers, leading new car development projects (interface function between marketing, engineering, procurement, strategy and finance), as well as total quality management (engineering) and public relations. These departments were assumed to have a good overview of the emission scandal's effects on corporate strategy and long-term developments. On the other hand, employees from sales subsidiaries in Germany, the United Kingdom and the United States were selected. Thereby, the subgroup can give an overview on short-term and operational effects of the scandal on two of the most important geographical markets for the automotive industry. Further information on each interview participant is available in *Appendix 2*.

Table 3: *Participant Overview*

Participant #	Category	Position	Duration [Minutes]
01	Corporate	Quality Management Product Strategy	48:08
02	Corporate	Product Manager Mid-Size Coupe Facelift	35:56
03	Corporate	Product Manager Mid-Size Coupe New Model	50:29
04	Corporate	PR Spokesperson Electric Vehicles	18:14
05	Corporate	Product Manager Mid-Size Sedan New Model	30:38
06	Market Subsidiary UK	Product Operations Manager, Cross Functional	53:04
07	Market Subsidiary UK	Head of Product and Market Planning	58:43
08	Market Subsidiary GER	Team Leader Product Management	43:13
09	Market Subsidiary US	Head of Product Management USA	45:24

6.3. Ethics & Data Collection

The topic of the emission scandal is currently considered a very sensitive topic in the automotive industry. For all participants, the correct handling of the raw data, as well as the results, was

a requirement to participate in the study. Therefore, the following measures were taken in collaboration with *the company* before beginning the data collection process:

(1) Restriction of publication: The thesis report, as well as the data, will only be made available to the supervisors, as well as the examiners of the master thesis.
(2) Anonymization of all participants and *the company*'s name in the final report.
(3) Explanation of participants' rights and protection per EU Article 7 & 8 before conducting the interview.

A semi-structured interview guide was prepared before conducting the interviews (see *Appendix 3*). The general framework of the interview is established by structured questions, to ensure all relevant information towards the three given investigative questions was collected. All questions were open-ended, to not bias the participant and allow for the observation of previously undiscovered perspectives. To dive deeper into certain topics of interest and the expertise of each participant, additional questions were asked on an ad-hoc basis during the interview. Moreover, each participant was asked five quantitative questions at the end of the interview, to summarise the influence of environmental regulation and consumer preferences, as well as evaluate current firm behaviour of the automotive industry. The duration of the interviews is presented in *Table 3*. The average duration was 42:39 minutes, but varied, as some participants were willing to give more detailed explanations than others. The interviews were conducted via telephone or an equivalent IP-based technology (Skype, FaceTime), recorded and subsequently transcribed. The transcriptions were then treated as the raw data for further analysis and are available in *Appendix 5*.

6.4. Analysis & Interpretation Process

The overall goal of the data analysis was to understand firm behaviour in the German automotive industry after the emission scandal. Therefore, the raw interview data was analysed in a

two-step cyclical process: (1) Data Coding and (2) Pattern Matching (based on Blumberg, Cooper & Schindler, 2014; Crouch & McKenzie, 2006; DeCruir-Gunby, Marshall & McCulloch, 2011; Yin, 1981; Yin 2003). This process is well suited for a single case study approach, because a comparison with theory increases the internal validity of the study and its cyclical nature increases the reliability of the results (Yin, 2003).

The coding process structures the data for further analysis. The software 'Annotations' was used to digitalise the coding procedure and facilitate the cyclical nature of the analysis, going back and forth between theory, collected data and other sources evidence. Codes were structured in categories, separating descriptive statements on changes in the perception of exogenous factors and firm behaviour from explanatory statements. The initial set of codes was established through the investigative questions (structure-driven), but new codes were added directly from the data (data-driven) or from related theory (theory-driven). A full overview of the final codebook can be found in *Appendix 4*. The raw data was coded collectively exhaustive and all statements, sorted by code, can be found in *Appendix 6*.

The second step of the analysis followed a pattern matching process. Identified statements on connections between exogenous factors and firm behaviour were compared between participants, as well as with relevant existing theoretical and empirical evidence. To yield the best result, a cyclical approach to data analysis was used. Data collection and data analysis overlapped to be aware of a saturation point for specific topics during new interviews. As new themes emerged either from the data or from relevant theory, previously coded interviews were re-evaluated. To complement the pattern matching analysis, a basic sentiment analysis was conducted with the raw interview data. The publically available software *Alchemy Language* offers text analysis through natural language processing to identify sentiment (positive or negative; scale -1 to 1), as well as the emotions anger, disgust, fear, joy, sadness (scale 0 to 1; IBM Corp., 2016). The results of this process are presented in the following chapters.

7. Data Analysis

This chapter structures *the company*'s perception of the emission scandal's effects. The interviews contained information regarding changes in exogenous factors in the market (Investigative question 1) and changes in operational, as well as strategic firm behaviour (Investigative question 2). The frequencies of certain statements will be used to present the relative importance of topics more objectively. A table with all frequencies can be found in *Appendix 7*. Additional evidence will be introduced to support or oppose statements from the interviews, if relevant quantitative data is publically available. In general, the description focuses on the European market (incl. sales subsidiary interviews in Germany and United Kingdom). Due to the unavailability of current European new car registration data, statistics on the German market are used as an example to support statements from the interviews. Specificities for the United States, as well as Asian markets, are presented separately in the last section to provide background information.

7.1. Demand Shifts after the Emission Scandal

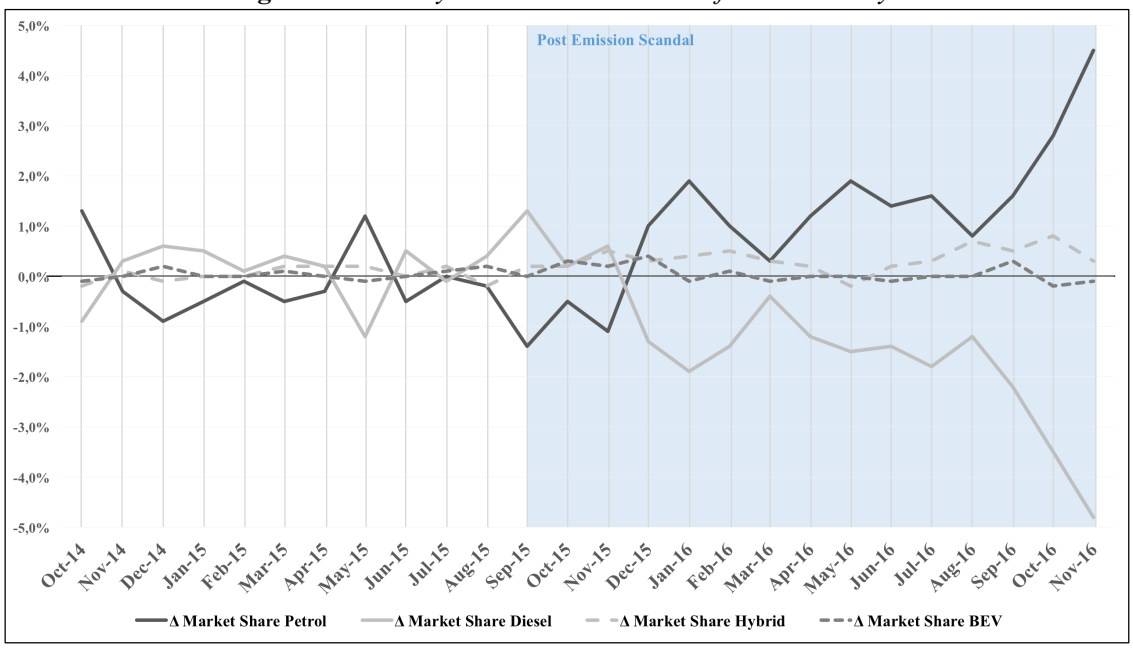
In the year after the emission scandal, *the company* noticed several ways, in which the mix of sold vehicles was affected. **First**, there was a shift from diesel to petrol models. Seven participants mentioned this change was noticeable, but "not of (…) high volume" (Participant 08).[5] *Figure 1* provides an illustration of year-over-year (YoY) changes in market shares of relevant drivetrain technologies on a monthly basis.[6] As data on a European level was unavailable, Germany is shown as an illustrative market. Whereas diesel is gaining up to 1% in market shares from petrol vehicles in the year before the emission scandal (October 2014 to September 2015), the year after the scandal shows a continuous decrease in the share of diesel vehicles by 0.3% to 4.8%. Inversely, petrol market shares increased 0.3% to 4.5%. The example only refers to the

[5] Interviews were conducted in November 2016. Therefore, participants were unaware of sales shifts in November 2016.

German market, statements from the interviews suggest the shift is generalizable to the Western Europe.

Second, participants gave mixed answers on the presence of a shift from diesel to low emission vehicles (PHEV, BEV). Four participants mentioned that they noticed the shift, whereas three participants explicitly stated that it was not present. New car registration data in Germany supports these mixed statements (*Figure 1*; KBA, 2016a). Depending on the market and the month, electric vehicles even showed negative year-over-year market share changes (-0.2% to +0.4%). The share of hybrid vehicles is growing at 0,2% to 0.8%, which can be traced back to growth in the corporate sector. Corporate and fleet consumers are more sensitive to emissions for reasons, such as fleet emission regulations and corporate social responsibility (e.g. Participant 06).

Figure 1: *Monthly YoY Market Share Shifts in Germany*[6]



[6] Monthly new car registration data was retrieved from the German Kraftfahrt-Bundesamt (KBA, 2016a). European and US-data was not publicly available. The illustration is a result of my own calculations (see *Appendix 8*). The calculation compares market shares to abstract from the total number of vehicles sold. To further abstract from seasonal differences in sales (e.g. corporate vs. retail), market shares were compared to the same month of the previous year, e.g:
$[\Delta\ YoY_{diesel}\ (Sept\ 2016)] = [\text{market share}_{diesel}\ (Sept\ 2016)] - [\text{market share}_{diesel}\ (Sept\ 2015)]$

Third, there is a shift from the Volkswagen brand to other brands (Frequency: 3), but these shifts often remained within the same drivetrain category (Participant 01). In the German market, new car registrations for Volkswagen decreased -3.4%, whereas the overall market grew +4.6% (KBA, 2016a). However, on the European level, this effect was not as strong, as Volkswagen sales increased by 2.8% YoY, compared to an overall market growth of 7.2% (ACEA, 2016a).

Fourth, *the company* noticed a shift away from outright retail purchases to financing and leasing models (Frequency: 3). Unfortunately, data to support or oppose this statement is scarce. New car registration data from Germany (KBA, 2016a) includes corporate usage, private ownership and car rentals, which include private leasing, but the agency aggregates financing with private purchases (see *Appendix 8*). Monthly year-over-year changes within each of these categories do not show a clear trend and both car rentals and private ownership averaged at 0.2% above last year's market shares. There no clear evidence to assume that a shift to financing and leasing models is generalizable to the whole market, but it might be specific to *the company* only.

The following sections will provide further details on how the interviewees explained these four effects through changes in public opinion, consumer preferences and environmental regulation.

7.2. Perceived Changes in Exogenous Factors

7.2.1. Public Opinion

The emission scandal received unprecedented media attention in the automotive industry (Frequency: 5). Volkswagen received the biggest share of negative press (Participant 04). The increased level of media attention shaped public opinion to be more critical on the topic of emissions and environmental regulation (Frequency: 5). Thus, diesel vehicles lost their image of being a cleaner alternative to petrol engines.

In addition, consumers lost their trust not just in the Volkswagen brands, but in the automotive industry in general, as there is now "(…) a general suspicion against everyone" (Participant 05). This distrust seems to supersede objective facts, such as positive retests of *the company*'s diesel vehicles (BMVI, 2016b). According to the participants, a lot of news reports were characterised by misinformation about technical details and the scope of the manipulations (Participant 02 & 04). Instead of focussing on the manipulations of NO_x emissions, public opinion was shaped by a more general discussion around emissions and fuel consumption (e.g. Participant 07 & 02). Hence, the public discredited the legitimacy of current emission test cycles, as current issues, such as the optimisation potential for manufacturers, became known beyond industry insiders.

7.2.2. Environmental Regulation

The following regulatory changes for the automotive industry were determined on a European level after the scandal:

(1) Retests for all diesel models in the market in Germany and the UK (BMVI, 2016b).
(2) Accelerated introduction of real-driving emission test (RDE) by one year, to accompany laboratory tests starting from September 2017 (European Commission, 2016). Due to real-world driving situations, the test will reduce current differences to laboratory tests, close optimisation loopholes, and limit the potential for cheating.
(3) Development of the new Worldwide Harmonised Light Vehicle Test Procedure (WLTP) was accelerated to replace NEDC in the future (BMVI, 2016b). The test is expected change currently reported results of car emissions in the range of – 11% to +16% (ICCT, 2014).

Participants reported these changes in the interviews with frequencies of two (vehicle retests), six (RDE) and three (WLTP). These changes are not radical deviations from existing regulation. Participants characterised them as an acceleration of previously announced measures, that were

known to the industry long before the scandal. Maximum emission standards (currently *Euro 6b*), as well as fleet emission targets were not increased yet after the scandal (Frequency: 3). An increase in regulation was therefore not felt in the operative business through newly introduced changes, but rather through legislation more thoroughly ensuring compliance with existing regulation (Participant 09). In the German market, the government also introduced subsidies for LEVs (€4.000 per purchase), jointly financed by the German Government and car manufacturers (BAFA, 2016). However, two participants pointed out that the subsidies were not a reaction to the emission scandal, but were planned independently as a general stimulus for LEVs.

With few concrete changes in environmental regulation after the emission scandal, participants focussed on their expectations towards future changes. Eight out of nine participants mentioned that they expect new regulations to become more stringent and implemented earlier than initially expected. In the past, European regulation has adapted to long development cycles in the automotive industry. Changes in regulation are usually announced early in the process to give manufacturers sufficient time to adjust their product portfolio accordingly (Participant 03). Nevertheless, these announcements initially remain very vague and then substantiate the closer they get to their introduction. Thus, the general mechanisms of European emission regulation will remain the same, but every planned future adjustment appears to be under revision. Whereas current regulation allows for some degree of interpretation and technical optimisation, future regulation is expected to close these loopholes (Participant 02). It is expected that most of these expected changes will only be felt in the operational business in 2020 and beyond (Participant 08). Moreover, the participants anticipate a stronger influence of local regulation (urban areas), which will impose manufacturers with new challenges in ensuring wide-spread compliance and consistent usage propositions across all drivetrains (Participant 06).

7.2.3. Consumer Preferences

Overall, *the company* did not notice a significant shift in purchase reasons among consumers in reaction to the scandal. Following exterior design, price is still the second most important purchase reason in most segments (Participant 02). In the purchase decision, the consumer often does not consider the cars emission (Frequency: 4), but the cost and risk factors he is perceiving (Frequency: 4). Thus, fuel consumption, which determines CO_2 emissions, slightly moved up in purchasing reasons. However, consumers are still not willing to pay a premium for being environmentally friendly (Frequency: 4).

Some consumers perceive current uncertainty about regulation as a risk factor, which might restrict intended usage patterns in the future. This leaves consumers with a feeling of "dispossession" (Participant 08). This reasoning may explain the moderate shift from diesel to petrol, as well as the shift from purchase to financing and leasing models as a measures of risk mitigation. Consumers who make outright purchases tend to use their car for a longer time. Thereby, this group perceives a higher risk on the car's resale value and its ability to fulfil its intended usage in the future, for example in urban areas. Choosing a financing or leasing model reduces the initial investment. Leasing models partly shift the risk of a lower resale value back to the manufacturer, or hide this risk in slightly higher monthly payments.

In the green segment, the argument of risk mitigation is accompanied by other changes in consumer preferences: On the one hand, the desire for environmental friendliness slightly increased (Frequency: 5), but on the other hand limitations, such as range, charging infrastructure and a higher price point, still impose the consumer with additional costs and risk. Hence, battery electric vehicles did not provide the majority of consumers with an option to mitigate their perceived risk on diesel vehicles. In contrast, plug-in hybrid vehicles do not disrupt current usage patterns in terms of range and charging and due to taxation provide especially corporate customers with a better alternative to diesel vehicles.

7.2.4. Impact of Environmental Regulation on Consumer Preferences

Five out of nine participants mentioned regulation as a lever on consumer preferences. As consumers are very price-sensitive, regulation has the power to influence their consideration set by indirectly adjusting prices and post-purchase costs (Participant 02, 05, 06). This effect appears to be of different magnitude for the corporate and retail segment. In the corporate segment, purchase decisions are more rational and driven by quantifiable factors (Participant 05 & 06). For example, diesel adoption in this segment over the past decades has been driven by its lower operating cost, resulting from lower corporate fleet and fuel taxes. The retail segment on the other hand is influenced not only by rational factors, but also by emotional purchase reasons. For example, retail customers look for superior driving experience in diesel models or the desire for a status symbol. Some countries, such as the Netherlands, were mentioned as markets, where high punitive measures drove the adoption of LEVs significantly above the European average, leading to average new car CO_2 emissions, which are approximately 27g/km lower than in Germany (Participant 06, ACEA, 2016a). As these kinds of incentives were not changed in reaction to the emission scandal, it is assumed that changes in adoption of LEVs in the retail segment were not directly caused by the scandal, however uncertainty about future fleet targets may have driven the adoption of PHEVs in the corporate segment.

7.2.5. Framework Validation & Alternative Factors

Overall, participants confirmed the influence of consumer preferences and environmental regulation to drive firm behaviour. In the quantitative part of the interview (see *Appendix 9*), participants ranked consumer preferences (5.94) and environmental regulation (6.44) as very relevant to explain firm behaviour.[7]

Participants were also asked, if they could identify additional drivers of firm behaviour that are unrelated to the emission scandal. They predominantly mentioned two macro-economic trends,

[7] Likert scale from 1 (=irrelevant) to 7 (=very relevant).

which are driving firm behaviour: The first is social and demographic change, including factors such as urbanisation and an increasing preference for pay-per-usage models (rental, car-sharing) over ownership (Participants 01, 07, 08). The second is political instability caused by the rise of populism in western countries, which manifests in citizen distrust against political elites, anti-intellectualism, polarisation of society and economic protectionism. These factors are decreasing consumer confidence and thus their willingness to make high expense purchases (Participant 06 & 09). These two factors are limiting market growth potential and manufacturers compensating by pushing vehicle sales beyond their natural demand (Participant 06 & 09).

Furthermore, seven participants named the threat of market entry as a driver of firm behaviour. Foremost, Tesla announced its Model 3 in March 2016 (Tesla Motors Inc., 2016). The new model is aimed at the mass market and will be delivered in mid-2018. Participants saw this entry as a threat, as the car is fully electric and supposed to come with a high range at a competitive price point in its class (Participants 02 & 03). Media attention regarding the emission scandal gave the announcement further momentum (Participant 02, 03, 09). However, Participant 05 mentioned that the announcement did not lead to a change of current roadmaps, as details on the vehicle are not yet fully published and it is unclear, whether Tesla will be able to achieve the proposed price at a premium quality level (Participant 01 & 03). Furthermore, IT companies, such as Google and Apple, are expected to enter the car market with new business models in the future. These companies are trying to leverage their competences in digitalisation to achieve truly autonomous driving for small city vehicles and shorten development cycles with over-the-air software updates and modular electronic components (Participant 01, 08). However, there is a lot of uncertainty about these potential new entrants, as well as evidence that the scope of their development projects was reduced significantly in the light of manufacturing entry barriers (Participant 03).

7.3. Changes in Firm Behaviour

7.3.1. Operational Firm Behaviour

The statements regarding changes in operational firm behaviour can be clustered in three categories: (1) External communication, (2) Product changes and (3) Price changes. Overall, consumer-facing operational measures were very moderate. Two participants did not report any short-term operational adjustments at all.

Reactions through external communication were present immediately after the scandal broke, as some manufacturers tried to capitalise on Volkswagen's losses and tried to convince consumers to switch to another brand (Participant 03, 09). Second, companies became stricter in their communication of fuel consumption data (Participant 04). At the same time, increased media attention also allowed companies to play the topic successfully in external communications on models with low emissions (Participant 02).

Six participants made statements regarding product changes, in the sense that they were not aware of any short-term model announcements, that were a reaction to the emission scandal. Participant 02 explained, that "(…) from a technical perspective, it's really hard to react short-term". Nevertheless, it is possible that some manufacturers accelerated the announcement of certain LEVs, due to increased public interest in the emission discussion. *The company* itself did not take such measures, but participants were uncertain about competitor behaviour. Second, some manufacturers had to take specific models off the market for rework after regulatory re-tests. However, these measures were short-term corrections on existing models to comply with regulation. If a new emission reduction technology was introduced, the technology must have already been developed before the scandal (Participant 02).

Price adjustments were also short-term and tactical, as five participants mentioned. MSRPs at *the company* have not changed, but some options, previously available at an additional charge,

became standard at the same MSRP, to keep resale values stable (Participant 08). Some competitors, including VW made use of discounts in the very short-term after the scandal to reach their existing sales targets on diesel vehicles. As diesel vehicles are already priced higher than petrol models (due to additional emission reduction technology), sales discounts did not provide manufacturers with a sustainable mean to maintain diesel market shares. After initial discounts, prices in the market are now rather moving upwards on these vehicles, as more emission reduction technology must be added to fulfil future regulations.

7.3.2. Internal Organisation

Five participants discussed changes to the internal organisation of *the company*. The first relevant aspect is corporate culture. Two participants gave detailed information on this topic, as they saw corporate culture as the main source of the manipulations at Volkswagen. Before the scandal, Volkswagen was characterised by a culture of fear with a hierarchical leadership style. Communication occurred mostly top-down and targets were not flexible to technical limitations. Middle-managers and engineers felt inhibited to speak up to top-level employees and saw cheating as the only option to achieve given targets. The two participants assume that a similar scandal would therefore not be a possibility within *the company*. From their perspective, *the company*'s top management has high ethical standards. A common understanding about technical topics is achieved through top-down and bottom-up communication and decisions are then made objectively on a common body of knowledge.

Nonetheless, the organisational complexity of manufacturers imposes all companies with the risk of supporting fraudulent behaviour in their corporate culture (Frequency: 5). Volkswagens losses quantified the risk in terms of financial consequences. Thus, all manufacturers are currently evaluating their corporate culture, as well as internal decision processes. Countermeasures to "tighten up" (Participant 07) the organisation include for example new internal communication guidelines, as a preventive measure in case informal communication documents (e.g.

employee e-mails) get leaked to the public in the future. Furthermore, *the company* increasingly quantifies risk factors in its business cases and decision processes, which has two effects. First, this led to a stronger focus on quality. *The company* now applies more long-term thinking to prevent potentially higher warranty costs in the development phase. Second, *the company* tries to overachieve current emission targets. Despite positive results of all vehicles in retests, *the company* is adding additional emission technology to its cars as a preventive measure against accelerated and stricter regulations. However, this technology will probably not be introduced to production vehicles, before compliance becomes necessary (Participant 01).

7.3.3. Strategic Firm Behaviour

Predominantly, the interviewees talked about long-term adjustments in firm behaviour. All nine participants made statements towards strategic firm behaviour, compared to seven for operational firm behaviour and five for internal changes. In the quantitative part of the interview guide (see *Appendix 9*), participants characterised firm behaviour after the scandal as explorative (5.11), proactive (5.28) and long-term (4.67).[8] The consensus among participants was, that firm behaviour became more explorative ensuing the scandal (Frequency: 7). Participants reported, that "(…) certain ways of thinking may have been triggered" (Participant 02) and that the whole industry appears to have a new perspective on "iconic change" (Participant 05) after the emission scandal. Participants assumed, manufacturers would not be able to achieve tightening emission regulation with their current product portfolio. Even though the theme of electric mobility is not new to the industry, current developments were characterised revolutionary (Participant 06), as participants observed companies trying to electrify high volume models in their portfolio (Participants 02, 03, 04).

[8] The participants were asked to evaluate the respective aspects of firm behavior in the German Automotive industry on a Likert scale from 1 to 7. A detailed overview of all quantitative results is available in *Appendix 9*.

As a result, companies increase their investment budgets and face new trade-offs, as less resources are available for customer-focussed innovation (Frequency: 4). At the same time, there is pressure to increase the average vehicle price, as more technology needs to be added to vehicles (Participant 03, 08, 09). Participants expected, that profit margins of OEMs will decrease in the upcoming years, because the consumer shows little willingness to pay for additional emission technology. Low cost brands, as well as VW will be adversely affected by this development (e.g. Participant 01). As VW is imposed to higher costs from various lawsuits, as well as lower sales, participants expected they would have to take lower profits or even losses for the next years and refocus their research and development investments more strongly than their competitors. In November 2015, Volkswagen revealed a new strategy to become the leader in electric mobility by 2015 (Volkswagen Group, 2016). According to the participants, this would not have happened without the emission scandal (Participant 05). In that sense, the emission scandal corrected the firm's perception of exogenous factors in the market (Participant 07).

Despite many statements hinting at explorative firm behaviour in reaction to the scandal, two participants were not convinced strategic firm behaviour changed significantly after the scandal. For example, Participant 04 was unsure, whether companies accelerated their plans, or only increased external communication efforts. Another participant from the German market had the impression, that changes to the *company*'s internal organisation were more significant, than strategic adjustments towards electric mobility (Participant 06).

7.4. Market Specificities

7.4.1. United States

Especially in the United States, where the emission scandal was first uncovered, the scandal had a different impact on exogenous factors in the market, as well as operational firm behaviour. Media attention ensuing the scandal was not focussed on consumption and emission topics, but on the Volkswagen Group committing fraud, which shaped public opinion accordingly (Participant 09). The scandal did not have a spill-over effect to other manufacturers (Participant 09) and there were no regulatory changes in the market.

However, diesel sales volumes still decreased significantly after the scandal (Participant 09). This has several reasons. First, diesel vehicles have a different positioning in the market. There is little cost advantage over petrol cars and market shares have remained low. Before the scandal, VW was the only brand selling a significant amount of diesel vehicles (Participant 09). After the scandal, VW had to remove all diesel models from its portfolio (Participant 09). This resulted in significantly lower sales of these vehicles in the market, as consumers are generally more loyal to their brand than a specific technology.

Second, the homologation process for diesel vehicles intensified after the scandal.[9] Whereas the process took four to six months before the scandal, authorities currently check diesel vehicles more thoroughly (Frequency: 3). Consequently, manufacturers are not able to introduce their vehicles as planned and have to delay them to the next upgrade cycle, foregoing sales and increasing costs. This uncertainty led some manufacturers to cancel planned market launches completely.

[9] Homologation is the process, in which authorities grant vehicle approval for market launch.

Third, the United States are a built-to-stock market. The consumer expects to be able to leave the dealership with a new car immediately after its purchase (Participant 09). Compared to Europe, which is a built-to-order market, the number of engine variants a manufacturer can offer is not limited by a critical mass of sales to amortise development costs, but by physical space at the dealerships. Dealerships had little incentive to keep diesel markets in their portfolio after the scandal, especially since plug-in hybrid models were providing consumers with a better value proposition in the green segment.

7.4.2. Asia

Six participants mentioned specifics, how Asian markets were affected by the scandal as well, giving evidence that the emission scandal had an impact on all three of the most important geographic regions for premium manufacturers (Europe, North America, Asia).

First, participants mentioned China as a market, where new regulations are oftentimes introduced with little lead time (Participant 03 & 08). These regulations vary regionally, rather than being introduced by the central government. Measures are often punitive and not incentivising (Participant 03). This leads to customer aversion of diesel technology, rather than stimulation of LEV demand. The expectation among participants was, that the emission scandal led to earlier and intensified fleet targets in this market (Participants 01 & 05), matching the effect of the scandal in Europe.

Second, participants mentioned South Korea as an exemplary geographical market, which is comparable to the United States, in the way that diesel vehicles were a growing, but not yet established category before the emission scandal (Participant 05). Furthermore, manufacturers had to deal with homologation delays, because of more thorough testing of new diesel vehicles. The combination of these two factors led to a reversal of previous growth in the diesel category (Participant 02).

8. Data Interpretation

To answer the third investigative question, this chapter will compare patterns in participant statements with theoretical concepts. Thereby, potential explanations for the influence of perceived changes in exogenous factors on organisational adaption can be established.

8.1. Lack of Operational Reaction

Firms in the German automotive industry did not show a strong operational reaction to the scandal. *The company* did not perceive a drastic shift of consumer preferences after the emission sandal. Only a few consumers appear to be driven by uncertainty about future regulation and taxation, but the shift in market shares from diesel to petrol keeps increasing. As established in the literature review, significant changes in consumer preferences and mobility patterns would be necessary to drive a shift to electric mobility (Dijk et al., 2013; Bohnsack et al., 2014). As this shift in consumer preferences did not occur, market conditions for LEVs remained unattractive.

Second, path-dependencies prohibited firms in the German automotive industry from immediate product portfolio adjustments. Five participants mentioned the inability to react short run, because of established product lifecycles (seven years) and development lead times. To deal with intensifying regulation in a sustainable way, technical changes will only be introduced with new car generations (Participant 08). For more radical innovations to gain traction in the market, changes in infrastructure, as well as the development of scale and learning effects are necessary to reduce the cost per unit (Kemp, 1994; Zapata & Nieauwenhuis, 2010).

This effect is catalysed by sunk investments in production capacities (Frequency: 3). The mass production of vehicles requires a high amount of experience, expertise and capital to overcome logistical challenges in the supply chain (Participant 03). Each production facility has a legacy

regarding models and platforms, which increases the cost of change (Participant 07). Moreover, the industry is already operating close to overcapacity (Participant 08). High sales volumes are needed to break even, which leads car manufacturers to safeguard their investments (Zapata & Nieuwenhuis, 2010). Thus, manufacturers focused on keeping market shares in place, instead of aiming for higher margins in the short-term (Participant 06 & 08).

8.2. Uncertainty driving Strategic Firm Behaviour

Participants in the interviews reported significant changes in strategic firm behaviour with companies increasingly engaging in explorative activities. Without significant immediate changes in the perception of exogenous factors after the scandal, *the company*'s expectations towards future changes appear to be driving its strategic reaction.

During the interviews, eight participants highlighted their expectations of future regulation to be introduced stricter and earlier. It is expected to become increasingly difficult for companies to find the right balance between ensuring compliance and sales growth (Participant 06). As local air pollutants are at the centre of regulatory discussions, they expect local regulation in urban areas to become more diverse. Consumer preferences on the other hand are not expected to change, as consumers will always make purchase decisions with regards to their financial means and intended usage patterns (Participant 02). Nevertheless, the importance of the indirect effect of regulation on firm behaviour via the adjustment of consumer buying behaviour will increase in the future (Participants 03, 06, 09). Thus, firms will "(…) put the investment where legislation is focused, because it's regulation that drives [consumers]" (Participant 06).

The influence of regulatory uncertainty on firm behaviour can be supported by academic theory. As established in the chapter four, organisational adaption theory assumes firms to make sequential decisions under uncertainty to determine their strategic positioning. Environmental regulation was found to be one of the main sources of this uncertainty (Posen & Levinthal,

2012). Changes in environmental regulation affect firms in their long-term development and are therefore very effective in stimulating firm reactions (Engau & Hoffmann, 2009; Rodriguez Lopez, Sakhel & Busch, 2016; Kim et al., 2012, Urpelainen, 2011). There are two kinds of uncertainty associated with environmental regulation: (1) regulatory uncertainty, about the scope and details of new regulation and the ability to comply, as well as (2) regulatory-induced uncertainty, about the effects of new regulation in the market (Rodriguez Lopez et al., 2016).

Regulatory uncertainty was found to lead firms to a postponement strategy (Engau & Hoffmann, 2009; Rodriguez Lopez et al. 2016). Having the possibility to invest in a certain strategy to cope with potential regulation can be treated like an option, whose value increases as regulatory uncertainty is reduced over time (Bernanke, 1983; Schwartz & Trigeorgis, 2004). The more regulatory-uncertainty exists, the higher the required investment and the lower the expected return, making the planning process ineffective (Rodriguez Lopez et al., 2016). Hence, firms delay their investment decisions until authorities clarify regulatory details. Instead, firms engage in lobbyism to influence the policy-making process (Engau & Hoffmann, 2009). As regulatory uncertainty dissolves and legislation clarifies their plans, firms increasingly start to base their decisions on regulatory-induced uncertainty and begin to invest accordingly. Firms aim to increase their flexibility to react developments following the introduction of a new regulation (Rodriguez Lopez et al., 2016).

There is evidence in the interviews, that this behavioural pattern is influencing firms in the automotive industry. The emission scandal stimulated a discussion about the severity of future emission regulation, which was reported by the participants in the form of more concrete expectations towards these changes. Thereby, the emission scandal reduced the uncertainty about the scope of future regulations (Frequency: 7). Future policies, such as new testing procedures, as well as increased emission standards and fleet targets, became more concrete. Gradually, firms are becoming more concerned with regulatory-induced uncertainty and make significant in-

vestments to increase their flexibility (e.g. Participant 01). As regulation is driving consumer buying behaviour, new expectations towards the regulatory environment increased expectations on sales volumes of low-emission vehicles (Participant 07 & 09). Consequently, some business cases for electric vehicles turned profitable, whereas small diesel vehicles with a lower profit margin are no longer feasible (Participant 07 & 09). Especially diesel vehicles must be equipped with more expensive technological solutions to comply with existing standards under the new test. These added costs will affect small diesel vehicles, where diesel engines might turn out to be no longer profitable for manufacturers and consumers (Participant 09). Considering long life and development cycles, as well as resale values on the used car market, firms are attempting to overachieve existing requirements in the current model portfolio. This allows them to remain flexible in both technological trajectories (ICE & LEV), however significantly increases the investments that are necessary to remain competitive in the market.

8.3. Organisational Adaption

Participants reported details on *the company*'s handling of ambidexterity after the scandal. A more dynamic environment appears to have led *the company* to re-evaluate the relationship between exploration and exploitation. Changes in resource distribution can give an indication on how the company plans to adapt across its subunits (ambidexterity), as well as within each subunit (punctuated equilibria). For the purpose of this analysis, *the company* consists of two subunits: To a major extent, the organisation is focused on exploiting ICE technology. On the other hand, the company established an exploratory subsidiary, focussing on the development of battery electric and plug-in hybrid technology for LEVs, and launched its first production vehicles several years before the emission scandal.

Eight participants made statements towards changes in ambidexterity across these two subunits. After the emission scandal, the overall focus appears to have shifted away from exploitation to more explorative activities. The whole industry faces an increase in investment needs, as partic-

ipants expect a tipping point in regulation that removes ICE technology from the market sometime in the future (Participants 02, 03, 04, 05). Participant 07 and 09 reported, that the *company*'s strategy was assessed more holistically in terms of synergies between different technological trajectories and potential future business models, which could be a further indicator of a shift between exploration and exploitation across the whole organisation. This switch in focus was expected to occur regardless of the emission scandal, but was accelerated by the effects the scandal had on exogenous factors in the market (e.g. Participant 08). Manufacturers other than *the company* will deal with ambidexterity in different ways, but all manufacturers will face a period of increased investment needs in both technological trajectories (Frequency: 4). For example, Participant 09 reported a "spectrum of [strategic] responses". For companies, such as Volkswagen, the changes potentially present a bigger reorientation and thus lead to an even stronger focus on exploration within the organisation (Participants 06 & 09).

As established in the literature review, punctuated equilibria can be present within each subunit of the organisation. Therefore, the two subunits (ICE and LEV) must be assessed individually for a change in focus from exploration to exploitation or vice versa (Gupta et al., 2006). Regarding electric mobility, participants reported that the technology is clearly seen as the one promising technology, which is suitable for the mass production of low emission vehicles (Participants 03, 07, 08). Therefore, current activities towards electric mobility present a logical next step for *the company*, but the roadmap has been accelerated after the scandal. *The company* became more proactive to bring these vehicles to the market as soon as possible (Participant 03 & 06). The focus of the subunit is starting to move to more exploitative search processes, as *the company* is trying to build efficiencies in terms of scale and scope in industrialisation, while at the same time exploring solutions to increase range and lower prices (Participant 02, 03, 07).

For the second subunit (ICE technology), the focus is slightly shifting from exploitation back to exploration. Participants highlighted the need to find new approaches, to keep ICE vehicles

compliant with future regulations (Participant 06 & 07). Participant 03 stated, that "the bar is so high, we really have to go out of our way to cope with it". Despite the realisation that the legacy technology has technical limitations, the consensus among the participants is that vehicles with internal combustion engines must remain competitive in the market for years to come. *The company* must ensure a gradual transition to electric mobility and bridge long lifecycles and development lead times (Participant 06 & 07). Consequently, the subunit needs to become more explorative and faces disproportionate costs on emission reduction achievements (Participants 01 & 05). The company is reacting by developing new emission reduction technologies earlier than planned and finding more holistic solutions, for example by promoting smarter usage of the vehicle (e.g. intermodality of public and private transport systems; Participant 06 & 07). Nevertheless, these developments do not present a complete reorientation for *the company,* but the rate of change increased significantly and the emission scandal had an accelerating effect (Participant 06).

8.4. Managerial Framing of Changes

Both organisational adaption theory, as well as literature on the effectiveness of environmental regulation, suggest that managerial perception of exogenous change is of importance. In organisational adaption theory, the challenge for firms is to assess exogenous factors in the market in advance (Posen & Levinthal, 2012). The evaluation of external change as an opportunity moderates the negative effects of ambidexterity and firms need to be sensitive to the exogenous environment to not disproportionately engage in exploitation (Atuahene-Gima, 2005; Bergek & Berggren, 2014). If the regulation is perceived as complementary to performance, it will influence strategic decision making accordingly and stimulate explorative behaviour and potentially radical innovation. On the other hand, if it is perceived as conflicting, managers will only try to minimise the cost of compliance and regulation can only achieve incremental improvements (Crotty & Smith, 2006). In this case, firms will not anticipate regulatory changes, and only ensure compliance immediately before such regulations are enforced (Barbieri, 2015). For these

reasons, this section analyses statements across the participants for the framing of exogenous changes, as well as changes in firm behaviour.

A basic sentiment analysis was conducted with the raw interview data.[10] The results of this analysis are provided in *Table 4*. Overall, participants remained rather neutral in their wording, with overall sentiments that were neither very positive, nor very negative (Average 0.03, standard deviation 0.17). Three participants each showed a slightly negative or positive sentiment.[11] On average, corporate participants showed a more negative sentiment, compared to a positive value for the market subsidiaries (Δ=-0,15). The participants used language that is associated with emotions of sadness (0.48) and disgust (0.28), suggesting the framing of changes as a threat. Furthermore, the language of corporate participants suggests they are less afraid of perceived changes (Δ=-0,13).

Table 4: *Sentiment Analysis*

Participant #	Sentiment	Anger	Disgust	Fear	Joy	Sadness
01	-0,19	0,14	0,11	0,2	0,24	0,49
02	-0,07	0,41	0,14	0,18	0,5	0,3
03	0,05	0,16	0,6	0,22	0,11	0,52
04	0,14	0,09	0,44	0,16	0,26	0,52
05	-0,11	0,39	0,48	0,17	0,16	0,54
06	0,16	0,47	0,1	0,15	0,29	0,49
07	0,35	0,12	0,4	0,5	0,19	0,48
08	0,08	0,12	0,1	0,5	0,16	0,5
09	-0,12	0,42	0,17	0,1	0,26	0,5
Average	**0,03**	**0,26**	**0,28**	**0,24**	**0,24**	**0,48**
Standard Deviation	0,17	0,16	0,20	0,15	0,11	0,07
Average Corporate	-0,04	0,24	0,35	0,19	0,25	0,47
Average Market	0,12	0,28	0,19	0,31	0,23	0,49
Delta Corporate/Market	**-0,15**	**-0,04**	**0,16**	**-0,13**	**0,03**	**-0,02**

[10] The publically available software Alchemy Language offers text analysis through natural language processing to identify sentiment (positive or negative; scale -1 to 1), as well as the emotions anger, disgust, fear, joy, sadness (scale 0 to 1; IBM Corp., 2016).

[11] Threshold was set at ±0.15. The default model is trained with websites and news content, in comparison to which the interviews were probably rather neutral in their language.

These mixed results can be replicated by qualitative statements from the interviews, as three participants each explicitly expressed concrete opportunities or threats resulting from the emission scandal. The mentioned opportunities include the following: First, *the company* is well positioned to react to changes, compared to competitors (Participant 09). Previous exploratory activities are now paying off (Participant 06) and *the company* can focus its efforts on finding holistic solutions that reconcile consumer preferences and regulatory requirements (Participants 07 & 08). Finally, changes in test cycles are expected to increase customer satisfaction in the future, once compliance can be ensured (Participant 06).

Some participants had a different perception and framed changes as threats. First, *the company* has to increase its investments, while at the same time there is little willingness to pay at the consumers. Participants therefore expect, that margins will decrease and business performance will remain below target in the upcoming years (Participant 01, 03 & 05). These participants also think, that consumer needs and regulation are not reconcilable and will develop in opposite directions. Furthermore, the participants blamed politicians for their reaction to the scandal by saying "(…) their demands are too excessive" and public opinion "(…) is not based on facts" (Participant 03). They feel powerless against the unsubstantiated suspicions against the industry (Participants 03 & 05).

These results highlight the need for further change management within the organisation. Otherwise, the adaption process will not be effective a change in ambidexterity will not yield the desired outcome. Nevertheless, the differences between market and corporate responses potentially results from a bias of corporate participants, most of which are working on vehicles built on ICE technology. The results should therefore be extended by further research beyond the product management department and sales subsidiaries to give a definitive answer towards managerial perception.

9. Discussion

9.1. Managerial Implications

The emission scandal led the German automotive industry into a phase of reorientation. An increase in media attention reshaped public opinion on the topic of fuel consumption and emissions, which influenced the perception exogenous factors in the market for German manufacturers. These changes expected to hit the market with a delay, but sales are increasingly shifting away from diesel vehicles. The case study provides four main implications:

First, *the company* did not show a significant operational reaction in 2016, as it did not perceive a drastic change in consumer preferences, nor environmental regulation immediately after the scandal. Furthermore, path dependencies limited manufacturers ability to react short-term.

Second, the emission scandal appears to have reduced uncertainty about future environmental regulations and consumer preferences among manufacturers, which led firms to engage in more explorative behaviour to increase their flexibility and address regulatory-induced uncertainty about future market conditions. As consumers are very price and risk sensitive, their purchase decision is highly influenced by regulatory developments. Thus, firms in the automotive industry have additional incentives to focus their development efforts on the direction of future regulation.

Third, firms re-evaluated and adapted the relationship between exploration and exploitation in their organisation. At *the company*, both subunits (ICE & LEV) appear to change away from their previous focus on either exploration or exploitation. Whereas for electric mobility, *the company* focusses on more exploitative search process to achieve economies of scale and scope for industrialisation, ICE technology needs more explorative search processes to simultaneously remain compliant with worldwide regulation and maintain a competitive cost position. These changes are not as much punctuated equilibria, as they present gradual changes, most likely to

occur over a longer transition period. Whereas these developments are only an acceleration of existing developments for *the company*, they impose other manufacturers with a bigger reorientation. In the context of high investment in both ICE and LEV technology, the average vehicle price could increase in the future. LEVs might then not become more competitive because they are more affordable, but because ICE technology will become more expensive for consumers.

Fourth, managers showed mixed results regarding the framing of change as either opportunity or threat. Changes in future regulation were rather perceived as threats in the short run. In the long run, new business models and developments in LEV technology are expected to provide *the company* with new opportunities to reconcile regulation and consumer preferences. Nevertheless, this perception needs to increase within *the company* and further change management will be required.

9.2. Academic Contributions

Academic contributions by this thesis are twofold. On the one hand, the case study advances the understanding of organisational adaption theory by providing a contemporary example. Gupta et al. (2006) called for the need to research more practical cases on how firms evaluate and frame changes in their external environment. The results show that other research trajectories, such as real options theory, help to fill this gap.

On the other hand, the case study provides new insights on the power of environmental regulation to stimulate radical innovations. It appears, that gradual increases in regulatory standards raise expectations towards a technological tipping point (as previously suggested by Hillmann & Sandén, 2008). Thereby, development lead times can be bridged. Furthermore, the case study gives new insights into the complementarity of environmental regulation and business performance. If firms cannot increase consumers' willingness to pay for emission technology and find means to reconcile consumer preferences and environmental regulation, the latter will lead to a

decrease in margins and firms are shifting resources away from other developments (as previously suggested by Kneller & Manderson, 2011).

9.3. Limitations & Future Research

As the thesis only considers a single case, its findings are hardly generalizable. The case only provides one unique perspective on the effects of the emission scandal and firm-perceptions of exogenous change. Due to data confidentiality, the number of participants was limited in this study. The mix of participants in a small sample could provide a source for bias. Furthermore, the coding process was only conducted by one individual. To establish more reliable results, multiple coders would need to assess the raw data independently (DeCruir-Gunby et al., 2011). Alternatively, the results could be confirmed or disconfirmed using replication logic, by conducting or comparing further case studies (Eisenhardt & Graebner, 2007).

Another limitation of this thesis lies in the fact that the transition of individual mobility in the automotive industry is an ongoing process. As the thesis is cross-sectional in nature, it can only report participants' current expectations for future developments. The persistency of changes in exogenous factors, as well as the results of explorative activities, are hardly predictable. Hence, the logical next step would be to test the results quantitatively across the automotive industry and monitor changes in longitudinal analysis.

Furthermore, the results can provide further research directions for organizational adaption theory that generalize findings beyond the case of the emission scandal. The case shows that firm expectations towards future changes in exogenous factors can induce changes in ambidexterity. Development lead times and managerial framing of change are potentially acting as mediators of this effect. These results should be considered for further quantitative research, as part of a two-stage design.

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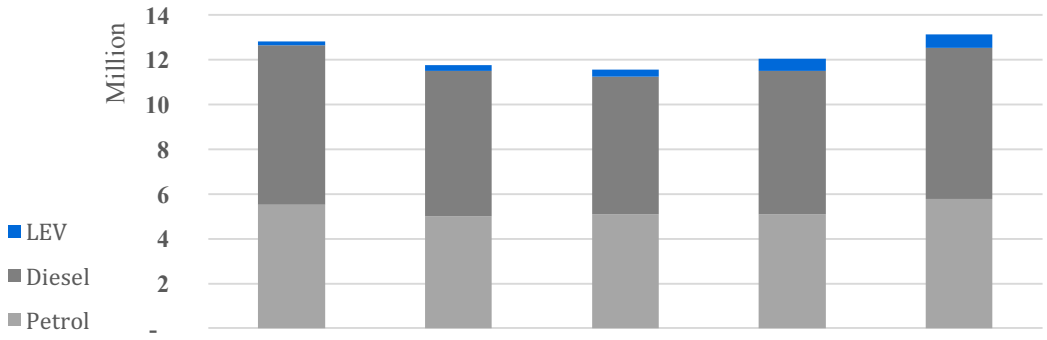
11. Appendices

Appendix 1: *New Car Registration Data Western Europe (2015)*



		2011	2012	2013	2014	2015
	Total Market Size	**12,812,844**	**11,773,467**	**11,554,096**	**12,051,710**	**13,126,270**
	Growth	**-1.3%**	**-8.1%**	**-1.9%**	**4.3%**	**8.9%**
Drivetrain Technology	Petrol	43.0%	42.6%	44.1%	42.3%	44.0%
	Diesel	55.7%	55.2%	53.3%	53.1%	51.6%
	Hybrid	n. a.	n. a.	0.3%	1.9%	1.4%
	Electric	0.1%	0.1%	0.3%	0.8%	1.4%
	Other	1,3%	2.1%	2.1%	1.9%	1.6%
OEMs	Volkswagen Group	22.9%	24.5%	24.8%	25.2%	24.4%
	PSA Group	12.6%	12.0%	11.1%	11.1%	10.8%
	Renault Group	9.3%	8.2%	8.7%	9.4%	9.4%
	Ford	8.0%	7.5%	7.4%	7.3%	7.3%
	Opel/GM Group	8.6%	8.0%	7.8%	6.7%	6.9%
	BMW Group	6.2%	6.6%	6.7%	7.1%	6.7%
	FCA Group	7.1%	6.5%	6.2%	6.1%	6.4%
	Daimler	5.1%	5.5%	5.8%	5.7%	6.2%
	Toyota Group	4.0%	4.2%	4.3%	4.2%	4.1%
	Nissan	3.4%	3.5%	3.5%	3.7%	4.0%
	Hyundai	2.8%	3.3%	3.2%	3.1%	3.2%
	KIA	2.0%	2.5%	2.6%	2.6%	2.6%
	Volvo Car Corp.	1.9%	1.9%	1.9%	2.0%	2.1%
	Mazda	1.0%	1.0%	1.2%	1.3%	1.5%
	Jaguar Land Rover	0.7%	1.2%	1.2%	1.2%	1.3%
	Suzuki	1.3%	1.0%	1.2%	1.2%	1.2%
	Honda	1.1%	1.1%	1.1%	0.8%	0.9%
	Mitsubishi	0.8%	0.6%	0.6%	1.0%	0.9%
	Others	1.2%	0.9%	0.9%	0.3%	0.3%
Structure Indicators	**German OEMs**	**42.8%**	**44.6%**	**45.1%**	**44.8%**	**44.1%**
	C_4	**52.9%**	**52.2%**	**52.0%**	**52.9%**	**51.9%**
	C_6	**67.6%**	**66.9%**	**66.5%**	**66.8%**	**65.4%**
	Herfindahl Index	**0.11**	**0.11**	**0.11**	**0.11**	**0.11**

	Brand	Segment Share 2015
Low Cost Segment (< €22k)	Renault	19.5%
	Peugeot	17.4%
	Fiat	13.4%
	Citroen	11.2%
	Hyundai	8.8%
	Kia	7.2%
	Seat	6.7%
	Dacia	6.6%
	Suzuki	3.3%
	Mitsubishi	2.6%
	Smart	2.0%
	Lancia	1.3%
	C_4	**61.5%**
	C_6	**77.5%**
	Herfindahl Index	**0.12**
Premium Segment (€30k - €50k)	Audi	25.4%
	BMW	24.6%
	Mercedes Benz	24.3%
	Volvo	9.3%
	MINI	6.3%
	Land Rover	4.7%
	Jeep	2.8%
	Jaguar	1.4%
	Lexus	1.2%
	C_4	69.2%
	C_6	97.4%
	Herfindahl Index	**0.20**

	Brand	Segment Share 2015
Medium Segment (€22k - €30k)	Volkswagen	30.2%
	Ford	17.8%
	Opel	16.3%
	Nissan	9.7%
	Toyota	9.4%
	Skoda	8.4%
	Mazda	3.6%
	Honda	2.2%
	DS	1.4%
	Alfa Romeo	1.0%
	C_4	**74.0%**
	C_6	**91,8%**
	Herfindahl Index	**0.18**
Luxury Segment (>€50k)	Porsche	82.2%
	Ferrari	5.5%
	Maserati[12]	5.5%
	Chevrolet	3.0%
	Lamborghini	1.8%
	Bentley[12]	1.8%
	C_4	96.1%
	Herfindahl Index	**0.68**

Sources: ACEA (2016a), Eurostat (2016)

Segmentation is based on average vehicle price by brand, retrieved from ICCT (2016c).

[12] *Segment share was retrieved consolidated with the brand above. For the calculations, a fifty-fifty split was assumed.*

Appendix 2: *Participant Background Information*

Participant #	Position	Focus of Work	# Years in the Automotive Industry
01	Quality Management Product Strategy	Product Management Product Marketing	24
02	Product Manager Mid-Size Coupe Facelift	Product Management Product Marketing	15
03	Product Manager Mid-Size Coupe New Model	Sales Controlling Product Strategy Price & Volume Planning Product Management	19
04	PR Spokesperson Electric Vehicles	Product Management	5
05	Product Manager Mid-Size Sedan New Model	Product Strategy Product Development Product Management (options)	12
06	Product Operations Manager, Cross Functional	Fleet Management Leasing UK Market at multiple OEMs	14
07	Head of Product and Market Planning	Sales & Aftersales UK market	30
08	Team Leader Product Management	Product Management (corporate) Retail	13
09	Head of Product Management USA	Services Product & Brand Strategy, Product Management (corporate)	14

Appendix 3*: Interview Guide*

(1) Explain scope and aim of the thesis, as well as participants' rights to data protection according to EU Charta Article 7 & 8.

a. Protection of personal data: Anonymised in final report
b. Data used only for the purpose of this thesis
c. Confidentiality Clause: Neither thesis, nor raw data, will be accessible beyond grading professors

(2) Record general facts about respondent and the organisation & establish qualification of the participant.

a. # years of experience in the German automotive industry
b. Focus of work

(3) Establish common understanding about the events of the emission scandal.

a. Did you perceive changes in environmental regulation? If yes, how?
b. Did you perceive changes in consumer preferences & societal pressure? If yes, how?
c. Did you perceive any other changes? If yes, which and why?

(4) Explore changes in firm behaviour ensuing the emission scandal.

a. How would you characterise the direction price-product measures in the automotive industry in 2016? Which changes occurred and why?
b. How would you characterise the strategic changes made by German car manufacturers in 2016?
c. Which elements of firm behaviour are changing in 2016?

(5) Explain reasoning behind change in firm behaviour.

a. How would you connect the industry effects of the emission scandal to the firm reactions?
b. How do firms reconcile consumer preferences and environmental regulation?
c. Are there any other influencing forces, not directly related to the emission scandal, that affected firm behaviour in 2016?

(6) Summarising questions.

a. Are there any relevant aspects of the topic that we did not talk about yet?

Appendix 4: *Codebook*

Category	Code	Source	Definiton	Example Quote
Sales Shifts	Diesel to Petrol	*Data-driven*	Statements about the presence of sales shifts from diesel to petrol vehicles	"And you can see it in sales numbers that especially diesel vehicles show a decline in sales because of it" (Participant 03)
	Diesel to LEV	*Data-driven*	Statements about the presence of sales shifts from diesel to low emission vehicles	"Equally I think we've seen greater migration to alternative drivetrains such as PHEVs, range extenders and pure BEVs as well" (Participant 07)
	VW to others	*Data-driven*	Statements about the presence of sales shifts from the Volkswagen brand to other brands.	"Customers are moving away from VW, but they are staying in the same category, just with other manufacturers" (Participant 02)
	Purchase to Funding	*Data-driven*	Statements about the presence of sales shifts from purchase to leasing- and financing models.	"The buyers are a little bit more sensitive. They usually use it for much longer, compared to a leasing customer" (Participant 08)
Public Opinion	Societal Trust	*Data-driven*	Statements of participants indicating a loss of trust and reputation in the German automotive industry.	"The customers feel like the automotive industry is kidding with them" (Participant 04)
	Media Attention	*Data-driven*	Statemtents reporting increased media coverage of the scandal.	"In our media evaluation, we never had a topic that was discussed so intensely for such a long time in the automotive industry" (Participant 04)
Consumer Preferences	Sales Shifts	*Structure-driven*	Statements of participants noticing sales shifts after the emission scandal	"What we do notice, is that there is a shift, however not of insanely high volume, back to petrol cars" (Participant 09)
	Consumption & Emission	*Data-driven*	Statements of participants about consumption and emission as a purchase reason	"The topic brought efficiency and fuel consumption higher up among purchasing reasons." (Participant 04)
	Risk Aversion	*Data-driven*	Statements of participants regarding risk factors in the consumers purchase decision.	"I don't think we saw any immediate drop of sales on those diesels, however consumers were probably looking to mitigate their risk, going on a funding mechanism rather than outright purchase." (Participant 07)
	Usage Patterns	*Data-driven*	Statements regarding intended usage patterns for specific vehicles	"On the one hand, its daily usage characteristics have to be covered by the car. If he has to commute, he knows he has to drive X kilometers a day, the car has to be able to do it. " (Participant 02)
	Willingness to Pay	*Data-driven*	Statements about the willingness to pay for emission technology.	"The customer is interested, as soon as it affects him financially and when there is regulation affecting this. Otherwise, he will continue to behave the same." (Participant 05)
Environmental Regulation	Expectations	*Data-driven*	Statements of participants having certain expectations about future environmental regulations	"Currently we expect that new more stringent regulations will be coming earlier than expected as a result of the emission scandal" (Participant 01)
	Changes	*Structure-driven*	Statements of participants about immediate changes in regulation after the emission scandal.	"In terms of environmental regulation, I am not aware that any new ones were added. What you can see, is that the federal agencies investigate more thoroughly and intensively, how regulations fulfilled in day-to-day use." (Participant 10)
	Influence on Consumer Preferences	*Theory-driven*	Statements of participants on how environmental regulation infuelnces consumer preferences.	"We always find that customers are driven highly be these kinds of incentives and you can look at other markets in Europe, where they have super high incentives on pure electric vehicles, the uptake on that is phenomenal" (Participant 07)
Alternative Explanations	Framework Validation	Structure-driven	Statements of participants validating the importance of environmental regulation and consumer preferences for firm behaviour in the automotive industry.	"No, I think this represents the situation in the US quite clearly" (Participant 09)
	Market Entry	*Data-driven*	Statements towards the relevance of new market entrants for firm behaviour.	"These are also IT companies that want our customer and they want while the car is driving itself, he can use the time to shop on their website and use their digital services. I don't think he will do that though. We have our competitors coming with new concepts as well" (Participant 09)
	Macro-economic Changes	*Data-driven*	Statements towards the relevance political volatility for firm behaviour.	"This leads to more uncertainty, especially which of the discussed changes will actually be implemented when the current president-elect is in office. This affects the import of cars, and which environmental regulations will be kept, which ones will be modified etc." (Participant 10)
Internal Organisation	Corporate Culture	*Data-driven*	Statements towards the influence of company internal beliefs and behaviours.	"I have experienced situations where heads of departments and board members are present, and they're obviously have a very dominant attitude. But you can still speak up, if you have a different opinion and explain your reasons, why you are against a certain decision" (Participant 01)
	Processes	*Data-driven*	Internal changes regarding processes, decision-making and treatment of information.	"Any manufacturer will have rigorous processes to make sure that couldn't possibly happen in their organization going forward." (Participant 07)
Operational Firm Behaviour	Portfolio	*Structure-driven*	Changes OEMs made to their product portfolio in reaction to the scandal	"There were some products that were taken off the market short-term. Some products were taken off for rework. Not from our perspective, but some companies had to rush into engineering changes" (Participant 07)
	Price	*Structure-driven*	Price changes that followed the scandal.	"And to summarize price measures, all very short-term and tactical" (Participant 09)
	External Communication	*Structure-driven*	External communication means in reaction to the scandal.	"For us not so much, because we always had correct data, but company's became more strict in their external communication" (Participant 04)
Strategic Firm Behaviour	Exploration	*Structure-driven*	Firm behavior that intends to achieve radical Innovation in the market place.	"Well – it had the effect, that the whole automotive industry changed their way of thinking, and I mean in a revolutionary way" (Participant 05)
	Exploitation	*Structure-driven*	Firm behavior that intends to capitalize on existing market structures through incremental innovation.	"Once the dust has settled, it's business as usual. As a result of the diesel-gate, everybody's tightened up, it's sharpened business practices for the long-term" (Participant 07)
	Investments	*Data-driven*	Statements regarding additional unexpected negative cashflows in the short-term for manufacturers because of the emission scandal.	"Yes, we have and will see additional cost to put further equipment into the vehicles. I think part of that cost will be absorbed by the manufacturers, but part of it will have to be passed on to the consumer. So there could be price rises due to that" (Participant 08)
Market Specificities	US	*Structure-driven*	Change in Firm Behavior on US market.	"The diesel will never reach this critical mass in the US. Its primary purpose is to fulfill greenhouse emission regulations" (Participant 10)
	Asia	*Structure-driven*	Change in Firm Behavior on Asian markets.	" I also think that in other countries, for example South Korea, there is a big aversion to diesel technology anyway. In these markets, were diesel is not established yet, it might reverse developments towards this technology" (Participant 02)
Lack of Operational Reaction	Development Cycles	Data-driven	Statements on the influence of development cycles as a lock-in mechanism.	"You cannot make short-term changes in the automotive industry. Life-cycles and development cycles are too long" (Participant 04)
	Capacities	Data-driven	Statements on the influence of production capacities cycles as a lock-in mechanism.	"As far as I know the automotive industry, this behavior is driven by the objective to keep market shares in place and fully utilize production capacities" (Participant 08)
Impact of Regulatory Uncertainty	Indirect Effect	Data-driven	Statetements on the impact of regulatory uncertainty by adjusting consumer purchase behaviour.	"The customer wants the newest engine with the lowest consumption, with the lowest CO2 emissions, with the lowest pollutant emissions. This is understandable. And in certain countries that is rewarded by the government through lower taxes, or bonuses, through one time payments" (Participant 03)
	Direct Effect	Data-driven	Statetements on the impact of regulatory uncertainty by directly targeting OEMs.	"The RDE bit is probably the part that has accelerated in development. My belief is that manufacturers are focused on the laboratory test, the regulatory tests, the real-driving emissions is a hugely important part" (Participant 06)
Organisational Adaption	Ambidexterity	Theory-driven	Statements providing information on the relationship of exploration and exploitation at the company and in the automotive industry.	"We more or less said: Let's take the perspective of the customer and the big picture perspective on what's going to happen with emissions and where we need to be. And based on this, we combined this with the topic electrification and changed our direction for that" (Participant 09)
	Punctuated Equilibrium ICE	Theory-driven	Statements providing information regarding a punctuated equilibrium within the ICE subunit.	"The bar is so high, that we really have to go out of our way to cope with it" (Participant 03)
	Punctuated Equilibrium LEV	Theory-driven	Statements providing information regarding a punctuated equilibrium within the LEV subunit.	"The technology is known and you want to have it on the market as soon as possible now" (Participant 03)
Managerial Framing	Opportunity	Theory-driven	Statements of participants framing changes through the emission scandal as an opportunity.	"This is definitely a good development, because it forces OEMs to find better solutions" (Participant 09)
	Threat	Theory-driven	Statements of participants framing changes through the emission scandal as a threat.	"In my opinion, we are going in opposite directions here. We have to invest a lot in clean cars, that the customer is never willing to pay" (Participant 05)

Appendix 5: *Raw Data – Interview Transcriptions*

- Available in a separate file.

Appendix 6: *Coded Data – Interview Transcriptions*

- Available in a separate file.

Appendix 7: *Frequency of Statements*

Section	Frequency			Topic	Frequency			P01	P02	P03	P04	P05	P06	P07	P08	P09
	Overall	Corporate	Market		Overall	Corporate	Market									
Sales Shift	9	5	4	Diesel to Petrol	7	3	4	x	x	x			x	x	x	x
				Diesel to LEV	4	1	3	x						x	x	x
				No shift Diesel to LEV	3	2	1		x		x		x			
				Volkswagen to other brands	3	3	0	x	x			x				
				Purchase to Financing & Leasing	2	0	2							x	x	
Public Opinion	7	4	3	Persistent Media Attention	5	3	2		x	x	x			x		x
				Decreased Societal Trust	5	3	2			x	x	x	x	x		
Consumer Preferences	7	5	2	Willingness to pay for emission tech.	4	4	0	x	x	x		x				
				Perceived Risk	4	2	2	x				x		x	x	
				Environmental Friendliness	5	3	2	x		x	x			x	x	
Environmental Regulation	8	4	4	Retests	2	1	1		x				x			
				Acceleration of RDE	6	4	2	x	x	x		x		x	x	
				Acceleration of WLTP	3	2	1		x			x			x	
				LEV subsidies no reaction to scandal	2	1	1		x						x	
				No fleet target increases	3	2	1		x	x			x			
				Expectation of Change	8	4	4	x	x	x		x	x	x	x	x
				Influence on Consumer Preferences	5	2	3		x			x	x	x	x	
Alternative Explanations	9	5	4	Market Entry	7	4	3	x	x	x		x		x	x	x
				Macro-Economic Changes	7	3	4	x	x		x		x	x	x	x
Organizational Changes	5	3	2	Internal countermeasures	5	3	2	x		x		x	x	x		
				Influence of Corporate Culture	2	2	0	x				x				
Operational Firm Behaviour	7	4	3	External Communication	4	3	1		x	x	x					x
				Tactical price measures	5	2	3	x	x				x		x	x
				Short-term Portfolio changes unlikely	6	4	2	x	x	x	x		x		x	
Strategic Firm Behaviour	9	5	4	Explorative Firm Behaviour	7	4	3		x	x	x	x	x	x	x	
				Exploitative Firm Behaviour	5	2	3	x			x		x	x		x
				Increase in Investments	4	2	2	x		x			x	x		
Market Specificities	7	5	2	United States	4	3	1		x	x		x				x
				Asia	6	5	1	x	x	x	x	x			x	
				Homologation delays	3	2	1		x							x
Lack of Operational Reaction	6	4	2	Influence of Development- and Lifecycles	5	4	1		x	x	x	x			x	
				Influence of Capacities	3	1	2			x				x	x	
Impact of Regulatory Uncertainty	8	4	4	Indirect Effect	6	2	4		x	x			x	x	x	x
				Direct Effect	7	4	3	x	x	x		x	x	x	x	
Organizational Adaption	9	5	4	Ambidexterity	8	4	4		x	x	x	x	x	x	x	x
				Punctuated Equilibrium Electric Mobility	5	3	2		x	x		x		x	x	
				Punctuated Equilibrium ICE	5	3	2	x		x		x	x	x		
Managerial Framing	7	3	4	Opportunity	4	0	4						x	x	x	x
				Thread	3	3	0	x		x		x				

Appendix 8: *New Car Registration Data Germany (2016)*

	Drivetrain Market Shares								Ownership Market Shares					
	Petrol	Δ YoY*	Diesel	Δ YoY*	Hybrid	Δ YoY*	BEV	Δ YoY*	Corporate	Δ YoY*	Rental & Lease	Δ YoY*	Private Purchase	Δ YoY*
Oct-14	50.9%	1.3%	47.5%	-0.9%	0.9%	-0.2%	0.3%	-0.1%	55.9%	3.8%	9.3%	-0.6%	34.8%	-3.2%
Nov-14	49.3%	-0.3%	49.1%	0.3%	0.9%	0.1%	0.3%	0.0%	57.4%	3.5%	9.9%	-0.7%	32.7%	-2.8%
Dec-14	49.5%	-0.9%	48.6%	0.6%	0.9%	-0.1%	0.4%	0.2%	59.0%	0.2%	7.5%	0.1%	33.5%	-0.3%
Jan-15	47.7%	-0.5%	50.6%	0.5%	0.9%	0.0%	0.3%	0.0%	58.3%	3.2%	10.5%	0.8%	31.2%	-4.0%
Feb-15	49.9%	-0.1%	48.6%	0.1%	0.9%	0.0%	0.2%	0.0%	55.9%	2.7%	11.0%	0.3%	33.1%	-3.0%
Mar-15	51.4%	-0.5%	46.9%	0.4%	1.0%	0.2%	0.4%	0.1%	52.7%	0.9%	11.5%	0.6%	35.8%	-1.5%
Apr-15	50.2%	-0.3%	48.2%	0.2%	1.0%	0.2%	0.2%	0.0%	52.5%	2.1%	12.4%	1.0%	35.1%	-3.1%
May-15	50.4%	1.2%	47.8%	-1.2%	1.2%	0.2%	0.2%	-0.1%	52.1%	2.9%	10.8%	-2.7%	37.1%	-0.2%
Jun-15	51.0%	-0.5%	47.4%	0.5%	0.9%	0.0%	0.3%	0.0%	53.8%	2.1%	10.4%	0.3%	35.8%	-2.4%
Jul-15	49.5%	0.0%	48.9%	-0.1%	1.0%	0.2%	0.3%	0.1%	53.8%	1.8%	10.7%	0.9%	35.5%	-2.7%
Aug-15	51.8%	-0.2%	46.5%	0.4%	0.9%	-0.2%	0.4%	0.2%	56.6%	4.4%	8.6%	-1.4%	34.8%	-3.0%
Sep-15	51.5%	-1.4%	46.8%	1.3%	1.1%	0.2%	0.3%	0.0%	56.6%	2.5%	12.4%	0.7%	31.0%	-3.2%
Oct-15	50.4%	-0.5%	47.7%	0.2%	1.1%	0.2%	0.6%	0.3%	56.6%	0.7%	9.4%	0.1%	34.0%	-0.8%
Nov-15	48.2%	-1.1%	49.7%	0.6%	1.4%	0.5%	0.5%	0.2%	57.3%	-0.1%	9.1%	-0.8%	33.6%	0.9%
Dec-15	50.5%	1.0%	47.3%	-1.3%	1.2%	0.3%	0.8%	0.4%	58.7%	-0.3%	9.2%	1.7%	32.1%	-1.4%
Jan-16	49.6%	1.9%	48.7%	-1.9%	1.3%	0.4%	0.2%	-0.1%	59.7%	1.4%	9.6%	-0.9%	30.7%	-0.5%
Feb-16	50.9%	1.0%	47.2%	-1.4%	1.4%	0.5%	0.3%	0.1%	56.7%	0.8%	11.2%	0.2%	32.1%	-1.0%
Mar-16	51.7%	0.3%	46.5%	-0.4%	1.3%	0.3%	0.3%	-0.1%	54.1%	1.4%	11.3%	-0.2%	34.6%	-1.2%
Apr-16	51.4%	1.2%	47.0%	-1.2%	1.2%	0.2%	0.2%	0.0%	53.1%	0.6%	12.0%	-0.4%	34.9%	-0.2%
May-16	52.3%	1.9%	46.3%	-1.5%	1.0%	-0.2%	0.2%	0.0%	51.2%	-0.9%	11.4%	0.6%	37.4%	0.3%
Jun-16	52.4%	1.4%	46.0%	-1.4%	1.1%	0.2%	0.2%	-0.1%	52.2%	-1.6%	10.6%	0.2%	37.2%	1.4%
Jul-16	51.1%	1.6%	47.1%	-1.8%	1.3%	0.3%	0.3%	0.0%	52.2%	-1.6%	12.2%	1.5%	35.6%	0.1%
Aug-16	52.6%	0.8%	45.3%	-1.2%	1.6%	0.7%	0.4%	0.0%	52.5%	-4.1%	9.4%	0.8%	38.1%	3.3%
Sep-16	53.1%	1.6%	44.6%	-2.2%	1.6%	0.5%	0.6%	0.3%	53.9%	-2.7%	11.7%	-0.7%	34.4%	3.4%
Oct-16	53.2%	2.8%	44.2%	-3.5%	1.9%	0.8%	0.4%	-0.2%	56.0%	-0.6%	8.6%	-0.8%	35.4%	1.4%
Nov-16	52.7%	4.5%	44.9%	-4.8%	1.7%	0.3%	0.4%	-0.1%	54.6%	-2.7%	10.8%	1.7%	34.6%	1.0%

*Example calculation: Δ YoY (Sept 2016) = market share (Sept 2016) - market share (Sept 2015)
Source: KBA (2016a)

Appendix 9: *Quantitative Questionnaire*

Item	Question	Scale	Explanation	P01	P02	P03	P04	P05	P06	P07	P08	P09
1	*How important is environmental regulation for firm behavior in the automotive industry?*	*Likert*	*1=irrelevant 7=very relevant*	7	7	6	7	7	6	4	7	7
2	*How important are consumer preferences for firm behavior in the automotive industry?*	*Likert*	*1=irrelevant 7=very relevant*	6	6	5.5	7	7	6.5	2	6.5	7
3	*And how would you characterize firm behavior in the automotive industry? (1/3)*	*Likert*	*1=exploitative 7=explorative*	5	5	7	6	3	6	4	6	4
4	*And how would you characterize firm behavior in the automotive industry? (2/3)*	*Likert*	*1=reactive 7=proactive*	6	5	7	7	4	4	5	5.5	4
5	*And how would you characterize firm behavior in the automotive industry? (3/3)*	*Likert*	*1=short-term 7=long-term*	6	6	4	6	4	3	4	5	4

Item	Question	Scale	Explanation	Overall		Corporate		Market	
				Average	Standard Deviation	Average	Standard Deviation	Average	Standard Deviation
1	*How important is environmental regulation for firm behavior in the automotive industry?*	*Likert*	*1=irrelevant 7=very relevant*	**6.44**	1.01	**6.80**	0.45	**6.00**	1.41
2	*How important are consumer preferences for firm behavior in the automotive industry?*	*Likert*	*1=irrelevant 7=very relevant*	**5.94**	1.57	**6.30**	0.67	**5.50**	2.35
3	*And how would you characterize firm behavior in the automotive industry? (1/3)*	*Likert*	*1=exploitative 7=explorative*	**5.11**	1.27	**5.20**	1.48	**5.00**	1.15
4	*And how would you characterize firm behavior in the automotive industry? (2/3)*	*Likert*	*1=reactive 7=proactive*	**5.28**	1.20	**5.80**	1.30	**4.63**	0.75
5	*And how would you characterize firm behavior in the automotive industry? (3/3)*	*Likert*	*1=short-term 7=long-term*	**4.67**	1.12	**5.20**	1.10	**4.00**	0.82